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Research Report 1731

Assessing Battle Command Information Requirements and the Military Decision Making Process in a Concept Experimentation Program

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14. ABSTRACT *(Maximum 200 words)*:

This report describes a concept experimentation assessment of battle command information requirements and military decision making in the 2010-2015 timeframe. This research was the first in a series of concept experimentation programs (CEPs) planned by the Mounted Battlespace Battle Lab (MBBL) at Fort Knox, KY, to re-engineer command and staff operations. This report focuses on research methods, exploratory results, and recommendations on method improvements for assessing battle command information requirements and the military decision making process (MDMP). The exploratory results provide a benchmark for future efforts and suggestions for improving information systems and future evaluations. Limitations and lessons learned on research methods are considered. Method recommendations address measurement approach issues, such as mission, enemy, terrain, troops, and time (METT-T) structure for determining information requirements, and the applicability of the MDMP in a real-time information environment. Recommendations on manual measures address the timing and scope of assessment and respondent workload. Finally, recommendations on instrumented measures stress reducing respondent workload and increasing measurement scope and precision.

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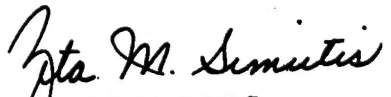
Education and Training Technology

FOREWORD

The Army's proactive effort to exploit advanced information systems requires research at the frontiers of the information age. Therefore, the Mounted Battlespace Battle Lab is conducting a series of Concept Experimentation Programs (CEPs) to explore advanced system capabilities and training requirements in the 2010-2015 timeframe. To support this CEP program, the U.S. Army Research Institute (ARI) joined this battle lab's CEP evaluation team. This team helped define initial research issues and lead evaluation efforts to address these issues.

Based on ARI's role in this CEP, this report describes research methods and results related to battle command information requirements and the military decision making process. The findings, although exploratory, provide a benchmark for future efforts and suggestions for improving advanced information systems. Limitations and lessons learned on research methods are considered. Recommendations for improving training and evaluation methods are provided. These recommendations stress the impact of advanced information systems on the process of meeting information requirements and making decisions. Method recommendations emphasize that advanced information systems are powerful research tools to help meet training and evaluation requirements.

This work was part of ARI's research program to train the force. The objective of ARI's Future Battlefield Conditions (FBC) team at Fort Knox is to enhance soldier preparedness through development of training and evaluation methods to meet future battlefield conditions. This report represents efforts under Work Package 2228 Force XXI Training Methods and Strategies (FASTTRAIN). The ARI's research on training requirements and evaluation methods is supported by a Memorandum of Agreement (MOA) between the U.S. Army Armor Center (USAARMC) and ARI. This MOA is titled Manpower, Personnel and Training Research, Development, Test, and Evaluation for the Mounted Forces, 16 October 1995.



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ASSESSING BATTLE COMMAND INFORMATION REQUIREMENTS AND THE MILITARY DECISION MAKING PROCESS IN A CONCEPT EXPERIMENTATION PROGRAM

EXECUTIVE SUMMARY

Research Requirement:

Research is needed to investigate concepts for re-engineering of the Tactical Operations Center (TOC) at battalion and brigade level, in order to take full advantage of information age technology. Recent Army Warfighting Experiments (AWEs) and other investigations have documented shortcomings in the Army's current command, control, communication, computer and intelligence (C^4I) systems. The Mounted Battlespace Battle Lab (MBBL) is conducting a series of Concept Experimentation Programs (CEPs) to explore new C^4I systems, organization and processes for the future battalion and brigade TOCs. The research described in this report used the first CEP as a vehicle to address two issues concerning the re-engineered TOC. The first issue, which related to new C^4I tools, was: How will a future maneuver battle commander's digital display meet the mission, enemy, terrain, troops and time (METT-T) information requirements of the commander? The second issue, which concerned potential changes in staff processes, was: Given the future battle commander's display capabilities, what are the changes to the decision making process?

Procedure:

Data collection concerning the two issues described above was integrated into the conduct of the CEP. Immediately after each of the three test missions, test players and observers completed surveys designed to address adequacy of C^4I systems to meet information requirements and changes in the decision making process. Comments in hot washes were also used to address the two issues.

Findings:

Results provided information addressing both issues, that is, how well the C^4I systems met staff information requirements and potential changes in the decision making process. Overall, the results indicated that test participants' information requirements were met or nearly met. Notably, none of the information components rated during the evaluation approached the level of "Exceeded." These results suggest there is a substantial need for C^4I system improvements to better meet information requirements. Concerning the second issue, there were few major changes reported by respondents concerning the military decision making process (MDMP). Overall, both test players and observers rated most sub-steps as "Unchanged." However, test players appeared more likely to rate MDMP steps as "Changed" than were observers. This finding, along with the questionnaire comments, suggested minimal changes in the MDMP during the CEP. Many questionnaire comments stress that the MDMP steps were performed in a less formal, more streamlined manner. Nonetheless, the steps were still performed. These findings are similar to those reported by Elliott, Sanders and Quinkert (1996) concerning training lessons learned from the Army Warfighting Experiment Focused Dispatch.

During Focused Dispatch, conventional doctrinal materials for the MDMP were available, but not their digital counterparts. The Task Force personnel in the CEP, as in Focused Dispatch, were creating new decision making tactics, techniques and procedures (TTP) during the evaluation. In the absence of new doctrine, participants fall back on old TTP and doctrine. Therefore, the lack of dramatic change in the MDMP during the CEP was not surprising.

Utilization of Findings:

The methods and results reported for this initial CEP provide a preliminary baseline for assessing information requirements and military decision making in future operations. The results are in no way definitive, but they provide a benchmark for future CEPs and related efforts. The results also provide many valuable user-based suggestions for both C^4I system and evaluation improvements. Specific limitations to the manual measures developed and used to assess information requirements and military decision making are also described. Recommendations to improve these measures are also addressed.

ASSESSING BATTLE COMMAND INFORMATION REQUIREMENTS AND THE MILITARY DECISION MAKING PROCESS IN A CONCEPT EXPERIMENTATION PROGRAM

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Introduction

This report describes research conducted to assess information requirements and military decision making as a result of advanced organizations and equipment for battle command. The purpose of introducing these innovations was to enable command and staff personnel from a battalion task force to take advantage of the information processing capabilities anticipated in the 2010-2015 timeframe. This research was undertaken as a part of a reengineered battalion tactical operations center (TOC) concept experimentation program (CEP), conducted by the Mounted Battlespace Battle Lab (MBBL) at Fort Knox, Kentucky. Here, only a brief overview of the background and method for this CEP is provided, as more complete reports are available.[1] After this overview, this report focuses on the methods used during this CEP to assess battle command information requirements and the military decision making process (MDMP), and the results and recommendations for method improvements. This report focuses on lessons learned for training and particularly evaluating information age forces.

Army Need

Although the Army has made substantial advances in incorporating digital technology into command and control systems in recent years, results of numerous simulations and field tests, including Advanced Warfighting Experiments (AWEs), show several deficiencies (USAARMC, 1998). First, individual digital systems (referred to as Command, Control, Communication, Computer and Intelligence [C^4I] systems, in this report) do not completely meet users' needs. As one example, the All Source Analysis System (ASAS) receives digital spot reports on enemy vehicle locations from platoon wingmen throughout the task force. The intelligence officer (S2) should then manually integrate or fuse these reports, and eliminate redundant information and icons. Thus while some low-level tasks of the intelligence section are automated by digital systems, others still remain, and new ones are created. Second, the Army's current C^4I systems such as the Army Tactical Command and Control System (ATCCS), are stovepiped or incompatible in that they communicate primarily within their own battlefield operating system (BOS). System incompatibility makes it difficult, for example, to portray a common picture of the battlefield situation on any one system or across systems. Finally, the current organization and operating procedures of a battalion staff may not be optimal for digital systems. Current organization is based on staff sections organized around a BOS. The assumption is that each section develops a separate piece of the puzzle, rather than all viewing an assembled puzzle.

The premise of the Army's recent series of AWEs was that advances in information technology have created the potential for a revolution in military affairs. Just as new weapon systems may dramatically change how we fight, information technology advances require an

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[1] For a more detailed discussion of the CEP design and methods see Elliott, Sterling and Lickteig (1998) and USAARMC (1998). For a more detailed discussion of the C^4I systems, also referred to as "tools," see the User's Manual (USAARMC, 1997).

equal examination. The Army, to date, has only automated its current organization and procedures. However, information technology changes the fundamental assumptions that underlie current Army operations and why the Army operates as it does. The Army should understand and prepare for future technology today if it is to utilize it tomorrow.

The Army needs to develop and implement lessons learned about C^4I systems to improve training and force development. Soldier-based research, such as the AWEs and CEPs, provides a venue for identifying, implementing, and refining lessons learned. For example, current procedures emphasize a lock-step method of commander, staff, and subordinate unit leaders all doing their tasks in a linear versus collaborative manner. Future staffs with C^4I tools will likely need a different, more rapid decision making procedure in order to take full advantage of the information dominance these tools will provide.

MBBL Approach

Numerous AWEs have documented deficiencies in legacy C^4I systems. Identified deficiencies include shortcomings in meeting user information requirements and supporting the military decision making process. This CEP, therefore, was based upon the premise that future technology would enable the creation of systems in which currently documented deficiencies in legacy C^4I systems would be substantially corrected. Thus, the MBBL directed its efforts to exploring issues arising when the currently identified C^4I deficiencies were corrected. Accordingly, the initial CEPs have at least two main objectives. First, to assess how well these improved C^4I systems have addressed these deficiencies. Second, if these identified C^4I deficiencies are corrected, how would this affect the future commander and staff?

To achieve the capabilities anticipated with advanced C^4I systems and prepare the Army future force operations, the MBBL initiated a series of CEPs to examine the effects of advanced digitization on battle command at brigade and below. As defined, battle command has three main elements. "Battle command is the art of battle decision-making, leading and motivating soldiers and their organizations into action to accomplish missions at least cost to soldiers and to the nation" (USAARMC, 1998, p. 2). The MBBL plan for these CEPs, called the Battle Command Futures Program, is to conduct a CEP approximately every six months for three years. These CEPs begin with a focus on battle command at the battalion task force level, and then progress to brigade. The objective of this program "is to develop an optimal battle-command solution for future commanders at the brigade level and below" (K. J. Gunzelman, personal communication, December 1, 1997). The approach requires the development and integration of futuristic technologies and investigation of the battle command staff organization that best exploits the capabilities provided.

The MBBL designed and executed the CEP. The Director of the MBBL made a decided commitment to advance the Army's investment in digital technologies by proactively exploring the potential of technology rather than retroactively documenting its limitations. The AWEs had repeatedly demonstrated that current, and therefore legacy, C^4I systems do not fully meet the Army's operational requirements. The MBBL's effort to develop an advanced C^4I system for lower echelon battle command resulted in some unprecedented capabilities and the opportunity for military users to directly and repeatedly assess their value in virtually simulated missions.

Lessons learned from this CEP will inform future Army efforts, including training, doctrine, and materiel requirements, as well as the MBBL's programmatic series of CEPs, and iteratively build toward an optimal battle command solution.

To support MBBL's efforts, the Armored Forces Research Unit (AFRU) of the U.S. Army Research Institute (ARI) joined the CEP evaluation team. The independent evaluation team was headed by the Test and Evaluation Coordination (TECO) Office at Fort Knox, Kentucky that is part of the U.S. Army Operational Test and Evaluations Command. The team assisted the MBBL in defining CEP research issues, and leading evaluation efforts to address these issues. Because of the resource and design limitations for this initial CEP, to include technical and control group shortcomings, the MBBL and the evaluation team concurred that the CEP was exploratory and the results preliminary. At TECO's request, ARI assumed primary responsibility for assessing the MBBL's CEP issues on battle command information requirements and military decision making. Another issue involving new skills, education and experience needed by future staff members was addressed by TECO alone. An independent report on the CEP (Elliott et al., 1998) was also published by TECO).

Methods

Method Overview for the CEP

This section provides an overview of the method for the first CEP conducted in December 1997 in the Mounted Warfare Test Bed at Fort Knox.

Participants

The participants were divided into two groups: test players and observers. The test players were 20 soldiers including a Lieutenant Colonel as the Task Force commander and two Majors as the executive officer and operations officer who were all from the 16th Cavalry Regiment and graduates of the Command and General Staff College (CGSC). Staff officers were recent Armor Officer Advanced Course (AOAC) graduates. Noncommissioned officers (NCOs) were from the 16th Cavalry Regiment or the 1st Armor Training Brigade. Of the 14 officers, 13 were Armor Specialty (Branch Code 12) and one was Infantry (Branch Code 11). Of the six NCOs, four were military occupational specialty (MOS) 19K and two were 19D. Notable features are that these test players represented an ad hoc versus an intact command and staff organization, and that only the commander had extended experience with digital C^{4}I systems.

The second group of participants, referred to as observers, were 10 soldiers from the 16th Cavalry Regiment Observer/Controller (O/C) team who also provided data for this experiment. During the CEP, these observers monitored test player performance and served as both data collectors and data providers. The observer group included two Majors, five Captains, and three NCOs. The Majors headed the observer team and led the hot washes after each mission.

Organization

In an attempt to take full advantage of the advanced C^4I systems simulated in the CEP, a new battalion staff organization was implemented. The new organization was similar to an organization that evolved in earlier work on C^4I systems by ARI (Leibrecht, Meade, Schmidt, Doherty & Lickteig, 1994). This re-engineered TOC structure is depicted in Figure 1. In contrast, a battalion TOC traditionally includes a main command post (CP) and combat trains command post (CTCP). The main CP has, at least, BOS representation for intelligence, operations, fire support, and mobility-countermobility. The CTCP handles the personnel and logistics functions for the task force. However, the re-engineered TOC consisted of four sections, referred to as nodes. These were the battalion commander's vehicle, a jump CP (with the executive officer [XO]), a current operations vehicle and a future plans vehicle. Each node had four soldiers. Except for the traditional roles of commander, XO and operations officer, the participants assumed more generic roles of enemy operations officer, friendly operations officer

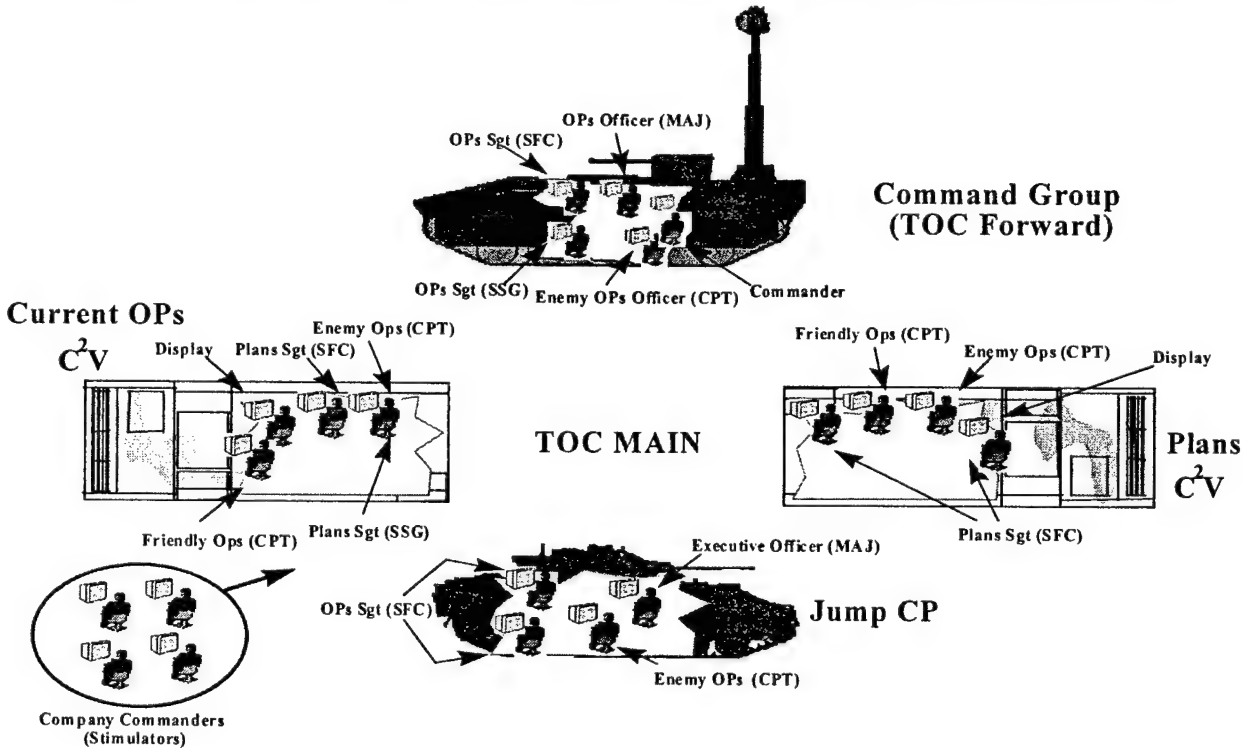


Figure 1. Overview of organization and equipment for the CEP.

or NCO, plans NCO and sensor NCO. Except for the battalion commander's battle command vehicle (BCV), which contained three officers and one NCO, the other nodes contained two officers and two NCOs. Overall, there were nine officers and seven NCOs.

Equipment

The suite of C^4I equipment for each of the four TOC nodes was identical. Figure 2 provides an overview illustration of how this equipment was configured in each node during the

CEP. For each node, separate monitors for the friendly operations officer, enemy operations officer and officer in charge (OIC) provided the "common picture." These monitors could depict either a two-dimensional plan view display or three-dimensional stealth view. In addition, the node OIC had a large screen monitor on which to display a stealth view, as well as a whiteboard. The unmanned aerial vehicle (UAV) sensor display was used by the enemy operations officer in each node. A brief discussion of each equipment item, or tool, is provided below. The Mounted Warfare Test Bed (MWTB) in which the CEP was conducted is a distributed interactive simulation (DIS) facility. It employs networked, selective fidelity simulators for manned entities and modular semi-automated forces (ModSAF) for unmanned entities. It is a soldier-in-the-loop environment, capable of crew through battalion-level, full mission simulation of realistic combat environments.

ModSAF. The ModSAF software was used to drive the DIS used in this CEP. The ModSAF simulates and controls entities that exist on a virtual battlefield. The ModSAF forces represent unmanned friendly forces and opposing force (OPFOR) entities. These entities behave

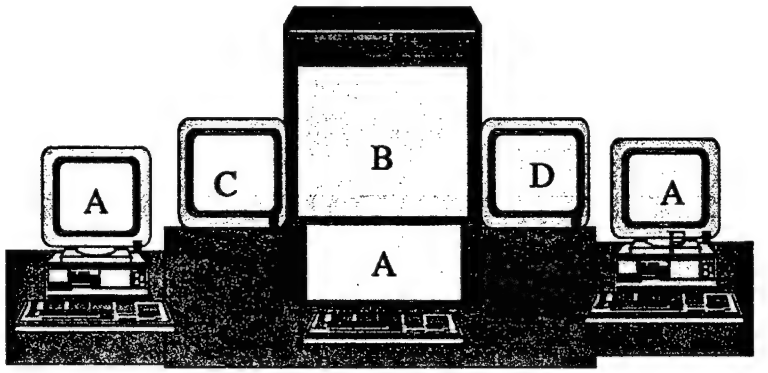


Figure 2. Overview of equipment for a node.
Note. UAV = unmanned aerial vehicle; VTC = video teleconference.

(i.e. move, shoot and communicate) autonomously, but remain under operator control (hence semi-automated), and interact over a network with each other and with manned simulators. The ModSAF was used to create many of the tool capabilities described below.

Plan View Display (PVD). The PVD, driven by ModSAF, generated and maintained situational information in the form of an electronic, two-dimensional (D) situation map (SITMAP). Key types of situational information routinely updated on this display included the location, identity and status of all friendly entities, and the location and identity of all sensed opposing entities. The PVD was designed to simulate correction of many of the identified deficiencies in the current, legacy C^4I systems. All friendly entities were represented, with positions continuously updated. For enemy entities, the PVD represented a "fused sensor" view

of the battlefield. All enemy entities within current range of any sensor (e.g., Joint Surveillance Target Attack Radar System [JSTARS], UAV, friendly battlefield platform) appeared on the PVD. However, these enemy entities were continuously updated only when within range of a sensor; otherwise the entity faded and eventually disappeared. Thus the PVD did not present an "all seeing" eye view of enemy activity, but only those enemy entities that were sensed. The PVD provided no interpretation of enemy force structure (e.g., Advanced Guard Main Body) but would aggregate enemy icons into units (e.g., platoon, company) using decision rules based on relative location of enemy icons. The PVD depicted terrain information drawn from a digital terrain database and provided various map tool features such as terrain analysis for line-of-sight determinations and a wide range of selectable map features (e.g., contours, grid lines, and buildings). The PVD also supported the creation and depiction of operational overlays based on a selectable set of control measures. However, no time estimates (e.g., time for friendly or enemy forces to traverse a certain distance) were available from any C^4I tools.

The PVD served as the primary C^4I display during the CEP and represented the future battle command display. The PVD provided the following functions: high resolution color display, relevant common picture, line of sight planning tool, stackable overlays, and fire support planning and execution capability. Detailed description of the capabilities of the tools associated with the PVD (and C^4I tools in general) are beyond the scope of this report, but are included in the user's manual (USAARMC, 1997).

Stealth Display. The stealth display provided test players a three-dimensional perspective view of the simulated battlefield. The situational information provided by the PVD and stealth display were identical; any enemy or friendly vehicles appearing on the PVD could also be seen on the stealth display. With the use of a "space ball," the officer in charge of each node could "fly over" the battlefield to visualize how both the friendly and enemy forces were arrayed on three-dimensional terrain.

UAV. A UAV in each node replicated the capability of obtaining information from a multitude of sensors, including unmanned ground sensors. The UAV was designed to assist with enemy reconnaissance and terrain analysis, in particular.

Whiteboard. The Whiteboard provided the officer in charge of each node the capability to copy all or part of the PVD screen at any time and draw graphics on the copy with the lite pen (mouse). For example, an operational overlay, course of action (COA) or operations order (OPORD) could be sketched out on the Whiteboard and transmitted to any other node. The Whiteboard could be used in conjunction with simulated radio and video teleconference (VTC) capabilities to conduct, for example, an orders brief or rehearse a mission.

VTC capability. The video teleconference capability allowed the commander and his staff to see and talk to each other on a flat screen display. It gave them a "face-to-face" capability to, for example, issue commander's guidance or receive input from the staff.

Electronic mail (e-mail). Nodes could send either free-text messages or overlays created on the Whiteboard to other nodes, subordinates (company commanders) or higher headquarters (role players for brigade staff).

Training

Test player training was conducted in the MWTB facility, in classrooms and bay areas. Table 1 depicts the schedule and types of training conducted. This training began with about two days of individual training on how to use the tools for their duty position and node. Although some individual training was conducted in MWTB in classrooms, the majority was hands-on training with the actual systems used in the experiment. Individual training was primarily provided by a group of personnel called research assistants. Next, small group and collective training occurred during approximately four days in which participants conducted a training mission and pilot mission. Research assistants were available throughout the training and trial missions to assist with problems encountered using the C^4I tools.

Observer training was conducted at the same time as test player training. Generally, the observer training consisted of monitoring test player training, although observers received hands-on training by the research assistants on the ModSAF and system tools on 2 December. Training for data collectors, observers, and members of the evaluation team was primarily provided in the form of a data collection rehearsal conducted after the pilot mission. Data management reduction personnel were trained during the test player and observer collective training period.

Evaluation Instruments

A demographic questionnaire was administered to the test players and observers to obtain information about prior military experience, including experience with digital information systems (Elliott et al., 1998). Four manual data collection instruments were used to address CEP research issues. Two of these instruments, Battlefield Visualization Tools and TOC Skills, Training, and Experience, are described and provided in Elliott et al. An Information Requirements Questionnaire (Appendix A) was used to assess battle command information requirements. An MDMP Questionnaire (Appendix B) was used to assess decision making. These questionnaires are both described later in this report. Other evaluation instruments used during the CEP, but not directly related to CEP research issues, are described in Elliott et al. In addition, manual and electronic recordings were made of test player comments during the CEP hot washes. These hot wash comments were also used to address both the research issues discussed in this report .

Procedure

As indicated in Table 1, the CEP began with an overview introduction in a classroom followed by a tour of the simulation bay's equipment and organizational configuration. Test players then received approximately two days of training on how to use the individual tools and spent four days conducting a training mission followed by pilot mission. All training and test missions were conducted on a terrain database for the National Training Center (NTC). The three test missions were movement to contact, deliberate defense and deliberate attack missions. During all missions a brigade cell monitored and coordinated the simulated exercise and provided instructions to ModSAF controllers for unmanned friendly and all opposing force entities.

Table 1

Training Schedule

Date	Time	Training
1 Dec	0800 - 0900	TOC Experiment Introduction
	0900 -1000	Commander's Time
	1000 - 1100	Walk-through tour and ModSAF overview
	1100 - 1500	Individual training with ModSAF tools at work stations
	1500 - 1600	One-on-one refresher training; individual training need identified
	1600 -1700	Hot wash (review of day events and lessons learned)
2 Dec	0800 - 1100	ModSAF/Tools - Individual skills training
	1100 -1200	Node internal review/Hot wash/Company Commander work station training observer training
	1300 - 1400	Video: DARPA TOC of the Future
	1400 - 1500	Tactical Decision Making Process; TOC Division of Labor (A Method)
	1500 - 1600	Individual skills verification/remediation
	1600 - 1700	Hot wash (Review/Lessons Learned/Data Instrument Overview)
3 Dec	0800 - 1600	Capstone TOC Collective Training Exercise (Issue Attack Mission OPORD)
	1600 - 1700	Hot wash (Army Research Lab Data Instrument Overview)
4 Dec	0800 - 1600	Continue Capstone Attack Mission Exercise (Plan/Prepare training)
	1600 - 1700	Hot wash (Task Force Commander's Lessons Learned)
8 Dec	0800 - 1400	Continue Capstone Attack Mission Exercise
	1400 - 1600	Hot wash (includes instrument data collection practice)
9 Dec	0800 - 1600	Continue Capstone Attack Mission Exercise
	1000 - 1030	Battlefield Visualization Class
10 Dec	0800 - 1600	Continue Capstone Attack Mission Exercise
	1600 - 1700	Hot wash (Lessons Learned)

Note. DARPA = Defense Advanced Research Projects Agency.

For all missions, the test players initially received a digital operations order from brigade, and then were required to plan, prepare and execute the battalion mission using the tools and organization previously described. Test missions lasted eight to nine hours from issuance of brigade OPORD until end exercise was declared or enemy forces were destroyed. Hot washes were held after each mission to address use of the equipment, training and information requirements, decision making, standing operating procedures (SOPs) and tactics, techniques and procedures (TTPs).

Manual evaluation instruments were administered after each test mission and at the conclusion of the CEP. The two evaluation instruments central to this report, the Information Requirements (IR) and MDMP Questionnaires, were only administered after each test mission, prior to the hot wash. The MDMP Questionnaire was provided to test players and observers in the simulation bay at their assigned duty stations. A member of the evaluation team distributed the questionnaire at each node and answered any questions about the instrument. The IR Questionnaire was provided to test players and observers in the same classroom used to conduct hot washes. A member of the evaluation team distributed the questionnaire to each participant and answered any questions about the instrument. Quality control procedures included verifying

completion of information, reviewing for interpretation of participants' handwritten information, and verifying the questionnaire corrections were completed. After data entry was completed, printouts of the database were made and verified and corrections made.

CEP Research Issues

The TOC re-engineering CEP was focused on three research issues (Elliott et al., 1998) . The first two issues centered on the battle commander's digital display, and the third issue addressed the skills, education and experience required for future command and staff personnel. Specifically, the issues were:

Issue 1. How will the future maneuver battle commander's digital display meet the mission, enemy, terrain, troops and time (METT-T) information requirements of the commander?

Issue 2. Given the future battle commander's display capabilities, what are the changes to the decision making process?

Issue 3. What skills, education and experience do commanders and staff need for future operations?

This report addresses only the first two CEP issues; for information related to the third issue see Elliott et al. (1998). While the focal point of issues 1 and 2 is literally the battle commander's digital display, the methods used to address these issues included the battle command displays and the entire suite of C^4I equipment used during the CEP. Advantages and limitations to this approach are considered in the discussion section. Given this overview of the CEP, this report now describes the methods used to assess battle command information requirements and the MDMP during the CEP.

Method for Assessing Battle Command Information Requirements

The lead research issue for this CEP was to determine how the future maneuver battle commander's display met the METT-T information requirements of the commander. Two methods were used to address this issue. First, an IR Questionnaire was developed to identify what information was required and how well information requirements were met. This questionnaire was administered to all participants (test players and observers) at the end of each test mission. Second, test player comments made during hot wash discussions were recorded manually and electronically.

Instruments

The IR Questionnaire is provided in Appendix A. This questionnaire used closed- and open-ended approaches to identify component types of information required by the participants' duty position, as played or observed, during the CEP. Closed-ended information components included in the questionnaire are listed by METT-T factor in Table 2. For each component, the questionnaire asked the participants' to indicate whether that type of information was "Required" or "Not Required." For each METT-T factor, an open-ended section followed that asked participants to identify any "Other" component types of information required. For each

component rated "Required," participants were then asked to indicate whether that requirement was "Not Met" "Met" or "Exceeded." For each component rated "Required" and any "Other" components identified, participants were asked to provide their recommendations on how that requirement might be better met.

Table 2

Information Components Used to Assess Battle Command Information Requirements by METT-T Factor

Mission	Enemy	Terrain	Troops	Time
Warning Order	Location	Observation	Location	Plan
Operations Order	Composition	Cover	Organization	War Game
Operations Overlay	Disposition	Concealment	Ability to See	Prepare
Commander's Intent	Ability to See	Obstacles	Ability to Move	Rehearse
Course of Action	Ability to Move	Key Terrain	Ability to Shoot	Execute
Fragmentary Order	Ability to Shoot	Approach Avenues	Ability to Communicate	Sync Execute
	Ability to Communicate	Weather	Ability to Sustain	
	Ability to Sustain			

Although the research issue addressed the information requirements of the commander, the questionnaire and hot wash methods assessed the information requirements for each of the primary duty positions occupied by the test players. The IR Questionnaire explicitly asked each participant to assess how well the information systems met the information requirements of "your duty position" during this CEP. The focus on all test players versus only the commander (a) expanded the test players' sample, (b) avoided confidentiality issues, and (c) provided results from key unit members who were expected to provide much of the information required by their commander.

Analyses

Empirical analyses were limited to descriptive statistics, given the preliminary nature of the data. For this report, mean values were computed for each METT-T component included and rated on the IR Questionnaire. For each component, two mean values were computed: one on information requirement identified, and the second on information requirements met. These means were computed across all participants (test players and observers), and across the three test missions conducted during the CEP. Missing data was excluded for each component, so sample size varied below N = 90 (30 participants x 3 missions). Participants comments from the IR Questionnaire and hot washes were subjectively analyzed to identify unique statements and provide approximate indications on the frequency of recurrent statements. More detailed analyses of the information requirements data were performed for the System Evaluation Report and Battle Lab Evaluation Final Report (Elliott et al., 1998; USAARMC, 1998). For these reports, separate frequency distributions and mean values for each IR component were computed on test player and observer ratings.

Method for Assessing the MDMP

The second research issue for this CEP asked what are the changes to the decision making process as a function of the future battle commander's display capabilities. Two methods were used to address this issue. First, an MDMP Questionnaire was developed to assess changes in the MDMP and decision making effectiveness and efficiency. This questionnaire was administered to all participants; test players (except UAV operators) and observers, at the end of each test mission. Although the sample size per item varied because of missing data, 12 participants and around 12 observers completed the questionnaire for each of the three missions for an overall N of approximately 72. Second, test player comments made during hot wash discussions were recorded.

Instruments

The MDMP Questionnaire is provided in Appendix B. It includes two parts, referred to as MDMP Step Assessment and MDMP Efficiency and Effectiveness Assessment.

MDMP Step Assessment. In the first part, each of the seven major steps and underlying sub-steps of the current MDMP were listed. Table 3 contains a list of the seven major MDMP steps and their sub-steps. The steps were based on the field manual (FM) Staff Organization and Operations (FM 101-5), as adapted for research and development purposes (Graves, Campbell, Deter, & Quinkert, 1997). For each step and sub-step, participants were asked to indicate whether the step or sub-step was "Unchanged," "Changed," "Combined" or "Eliminated." Definitions of these responses, and a sample item, as it appears in the questionnaire, are given in Table 4. If a step was rated as "Unchanged," all its sub-steps were automatically considered as "Unchanged." If a step was rated as "Eliminated," all associated sub-steps were automatically considered "Eliminated." Responses were re-coded, when necessary, to conform to these instructions. After rating a step and its sub-steps, participants were asked to provide written comments for any step or sub-step rated as "Changed" or "Combined." Comments clarified how the step or sub-step had been "Changed" or "Combined."

MDMP Efficiency and Effectiveness Assessment. In the second part of the questionnaire, participants were asked to rate both the effectiveness and efficiency of the seven major MDMP steps, as performed in the CEP, on a 3-point scale (1 = "Inefficient" or "Ineffective"; 2 = "Moderately Efficient" or "Moderately Effective"; 3 = "Very Efficient" or "Very Effective").

Table 3

Steps and Sub-steps for the Military Decision Making Process

Military Decision Making Process (MDMP)
Mission Analysis
Prepare initial Intelligence Preparation of the Battlefield
Analyze higher mission
Analyze Brigade (Bde) order
Assess risk
Briefing and approval
Course of Action Development
Analyze Commander's (Cdr's) guidance
Analyze relative combat power
Generate conceptual possibilities
Develop scheme of maneuver
Incorporate all battlefield operating systems
Wargaming
Follow wargaming method
Employ all friendly and enemy forces/resources
Identify critical events and decision points
Record results
Apply action/reaction/counteraction
Assess results
Course of Action Comparison
Select comparison method
Determine decision criteria and assign weighting values to criteria
Record results (COA decision matrix)
Orders Preparation
Incorporate Cdr's guidance
Identify who, what, where, when & why
Incorporate battlefield operating systems plans
Review & approve
Rehearsal
Define the standard
Orient participants to terrain
Verbalize concept of the operation
Select key events to rehearse
Describe enemy COAs
Focus on purpose of rehearsal (Decision Support Template, branches & Sequels, synchronization)
Mission Execution and Transition
(No sub-steps for this step)

Table 4

Questionnaire Response Definitions and Example Item

UNCHANGED – The entire step was performed the same way in the restructured TOC as in a conventional TOC. If you check "unchanged" for the step, do not check any blocks for the sub-step under that step. That is, if the entire step is unchanged, all sub-steps must also be unchanged.
CHANGED – The step or sub-step was still performed, but in a different way in the restructured TOC than in a conventional TOC. Under the comments section, please describe how the step or sub-step was performed differently. Individual sub-steps under the step may be unchanged, changed, combined or eliminated.
COMBINED – The step or sub-step was performed as a part of another step or sub-step in the MDMP in the restructured TOC. Under the comments section, indicate which other step or sub-step was combined with it. Again, sub-steps under the step may be unchanged, changed, combined or eliminated.
ELIMINATED – The entire step no longer needs to be performed at all in the restructured TOC. If you check "eliminated" for the step, do not check any blocks for the sub-step under that step. That is, if the entire step is eliminated, all sub-steps must also be eliminated.

	UNCHANGED	CHANGED	COMBINED	ELIMINATED
MISSION ANALYSIS				
- Prepare initial Intelligence Preparation of the Battlefield				
- Analyze higher mission				
- Analyze Bde order				
- Assess risk				
- Briefing and approval				
Comments: (required if changed or combined are checked) Also, please include the addition of any related new steps or sub-steps.				

Analyses

Empirical analyses were limited to descriptive statistics. Frequency distributions were computed for responses to each MDMP step and sub-step, by test players and observers. Means were calculated for effectiveness and efficiency ratings for each step, by test players and observers. A subjective content analysis was performed on the open-ended comments

concerning changes in the MDMP. These are combined comments from both test players and observers. In addition, comments concerning the MDMP during hot washes were recorded and reviewed. A synopsis of these hot wash comments is also presented.

Preliminary Results

This section provides CEP results on battle command information requirements and the MDMP. The results provided are based on test player and observer responses to the IR and MDMP Questionnaires and test players' hot wash comments.

Information Requirements

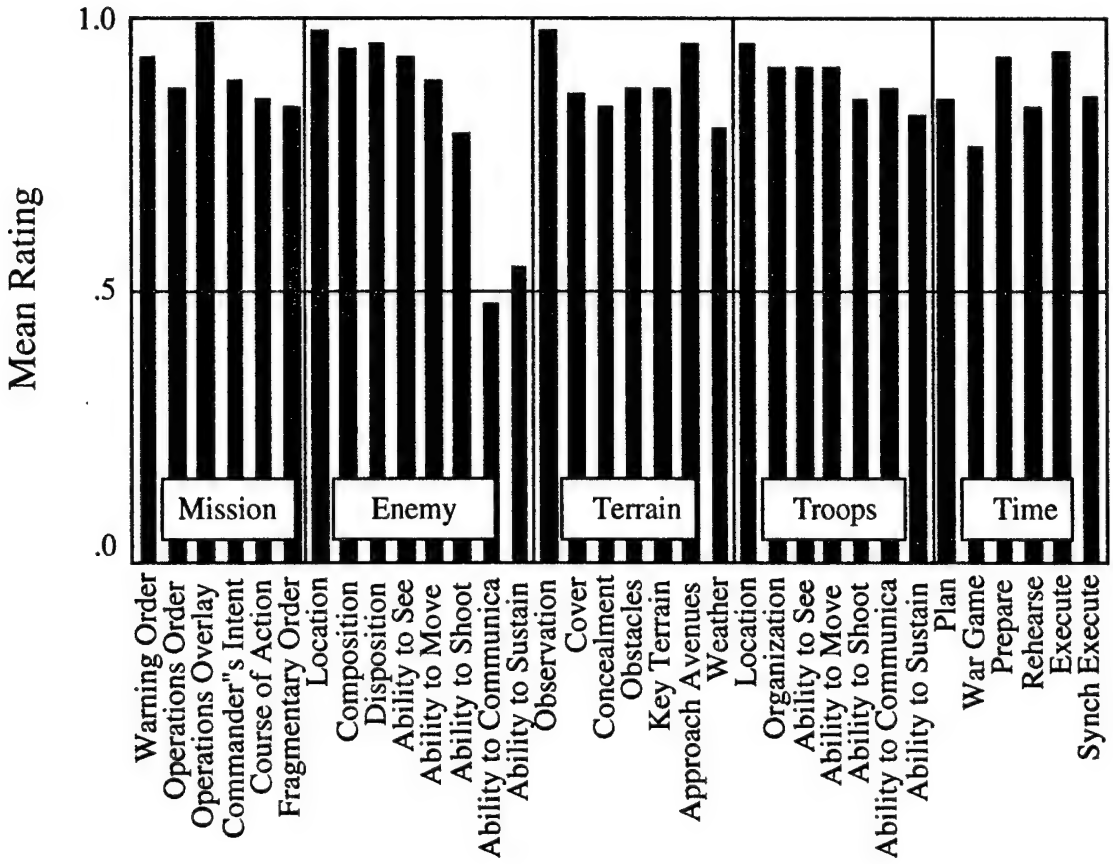
A summary presentation of the findings on METT-T information requirements identified is provided in Figure 3. This figure provides mean ratings for each component specified in the IR Questionnaire based on a two-level scale in which "Not Required" = 0, and "Required" = 1. A summary presentation of the findings on METT-T information requirements met is provided in Figure 4. This figure provides mean ratings for each information component specified in the IR Questionnaire based on a three-level scale in which "Not Met" = 1, "Met" = 2, and "Exceeded" = 3. A more detailed presentation of these results, including frequency distributions for each response category, are available (Elliott et al., 1998).

Overall, the results indicated that nearly all of the component types of METT-T information included in the IR Questionnaire were regarded as required information, and that many of these information components were rated as met or nearly met by the C^4I systems used in the CEP. Participants also identified "other" information components that were required but not specified on the IR Questionnaire, and participants provided many useful recommendations for improving C^4I systems to better meet their information requirements.

More detailed participants' comments from the IR Questionnaire and hot wash comments are considered in the discussion section. These comments address "other" information requirements identified by the participants but not specified in the IR Questionnaire, and participants' recommendations on how their information requirements might be better met. The remainder of this section will present results in the manner obtained from the IR Questionnaire, by the factors of METT-T.

Mission

The types of mission information components specified in the IR Questionnaire were generally identified as required information (see Figure 3). The average mean requirement rating across all mission components was .91. The mean component requirement ratings ranged from .87 for fragmentary order to .99 for operations overlay. Participants also identified other types of required mission information, not included in the IR Questionnaire. Numerous participants noted that typical missions routinely entail additional and/or more detailed information requirements than the CEP test missions. They stressed that information requirements in more typical combined arms operations include the planning and coordination of additional assets from brigade such as artillery and close air support, as well as supporting assets such as combat



Requirement Ratings: 0 = Not Required; 1 = Required.

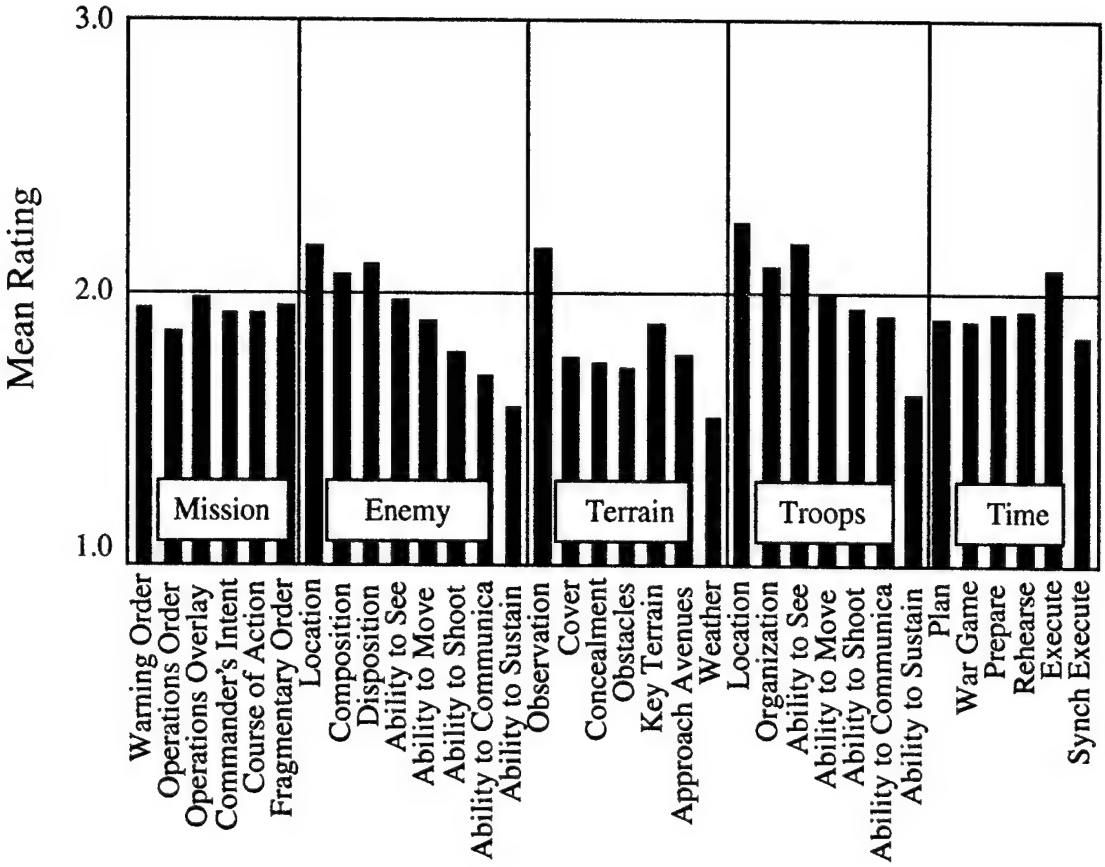
Figure 3. Information requirements identified by METT-T factor and component.

support, and combat service support. Similarly, participants repeatedly noted that their information requirements are generally intensified when there is more detailed planning and coordination of lower echelon units at company and platoon level.

Participants indicated that their mission information requirements were never fully met (see Figure 4). The average mean met rating across all mission components was 1.91. The mean component met ratings ranged from 1.82 for operations order to 1.98 for operations overlay. In sum, participants' ratings indicated their mission information requirements, as tested, only approached being met.

Enemy

The types of enemy related information components specified in the IR Questionnaire received very mixed ratings as required information (see Figure 3). The average mean requirement rating across all enemy components was .79. The mean component requirement ratings, however, ranged from .47 for ability to communicate to .98 on location. In particular,



Requirement Ratings: 1 = Not Met; 2 = Met; 3 = Exceeded.

Figure 4. Information requirements met by METT-T factor and component.

participants did not strongly endorse a requirement for information on ability to communicate or ability to sustain. Participants also identified other types of required enemy information. Several participants noted the requirement for information on assessing battle damage to the enemy. More specific recommendations suggested this assessment might distinguish catastrophic versus mobility kills. Participants also noted the need for information on enemy course of action. For example, one participant commented that "what do we expect the enemy to do is not addressed." Numerous participants reported that information on enemy dismounts was neither met nor attempted by their C^4I systems.

Participants provided mixed ratings on how well their enemy information requirements were met (see Figure 4). The average mean met rating across all enemy components was 1.90. The mean component met ratings, however, ranged from 1.60 for ability to sustain to 2.14 for location. Information on enemy ability to shoot, communicate and sustain received particularly low ratings. In sum, participants' ratings indicated their enemy information requirements, as tested, were met only for location, composition and disposition. Recall that many participants did not identify ability to communicate or ability to sustain as required information. Participants who did, however, strongly indicated that these requirements were not met.

Terrain

The types of terrain related information components specified in the IR Questionnaire were generally identified as required information (see Figure 3). The average mean requirement rating across all terrain components was .88. The mean component requirement ratings ranged from .76 for weather to .97 for observation. Participants also identified other types of required terrain information. Other terrain information requirements cited by participants included trafficability information, estimated rate of march, and obstacles.

With the exception of Observation information, participants' ratings indicated that their terrain information requirements were not met (see Figure 4). The average mean met rating across all terrain components was 1.80. The mean component met ratings ranged from 1.54 for weather information to 2.16 for observation information. Overall, participants' ratings of how well terrain information requirements were met were generally lower than those of other categories. Participants stressed the need for more accurate terrain data bases with more variable resolution, for information on obstacles and smoke, and for the ability to determine rates of march and mobility corridors for both enemy and friendly units.

Troops

The types of troop related information components specified in the IR Questionnaire were generally identified as required information (see Figure 3). The average mean requirement rating across all troop components was .88. The mean component requirement ratings ranged from .80 for ability to sustain to .96 for location. Participants also identified other types of required troop information. Numerous participants noted that information on their unit's ability to sustain operations was not adequately provided. In addition, they stressed the scenarios did not focus on sustainment requirements. More specific recommendations noted the need for information on close air support and battle damage effects on friendly weapon systems. For example, one participant stated "the commander would have better situation awareness if the crews could input their damage." While text-based sustainment information on friendly weapon systems was available via automated situation reports, at least one participant commented that a more graphic format such as "gumball" charts might be provided.

Participants indicated that their troop information requirements were very close to being met (see Figure 4). The average mean met rating across all troop components was 1.99. The mean component met ratings ranged from 1.62 for ability to sustain to 2.23 for location. Excepting information on their unit's ability to sustain, participants indicated their CEP information systems met or nearly met most component types of troop information.

Time

The types of time related information components specified in the IR Questionnaire were generally identified as required information (see Figure 3). The average mean requirement rating across all time components was .86. The mean component requirement ratings ranged from .77 for wargame to .94 for prepare and execute. Participants also identified other types of required time information. Numerous participants noted that the requirement to synchronize external

resources was neither met nor addressed. For example, one participant stated that close air support coordination in support of the task force was poor. Numerous participants also stressed that sufficient time was not provided for planning and preparation at company and platoon levels. Participants also stated that future exercises should provide a better digital brigade operations order to aid task force planning and preparation.

With the exception of execute, participants indicated that their time information requirements were never fully met (see Figure 4). The average mean met rating across all time components was 1.92. The mean component met ratings ranged from 1.78 for synch execute to 2.06 for execute. Participants' ratings clearly indicated their time information requirements, as tested, only approached being met.

MDMP Results

Results are presented first by MDMP steps. Then rating results on decision making effectiveness and efficiency are presented, and followed by hot wash results. Participants' questionnaire comments are integrated into the questionnaire results on MDMP steps. Comment categories, and the frequencies with which each were cited, are provided in Appendix C.

MDMP Step Results

Mission Analysis. A majority of all participants, (test players and observers) rated the step Mission Analysis as "Changed" (see Figure 5). However, the response to sub-steps was somewhat different. First, considering test players' responses for Mission Analysis, there were two sub-steps (Prepare Initial Intelligence Preparation of the Battlefield [IPB] and Briefing and Approval) where a majority of responses were "Changed." However, for the three other sub-steps (Analyze Higher Mission, Analyze Brigade Order and Analyze Risk) a majority of responses were "Unchanged." For observers, half or more of the responses were "Unchanged" for all sub-steps except for Prepare Initial IPB where the majority of responses were "Changed." A subjective content analysis of the written comments was conducted to clarify this pattern. Many of the comments indicated that the IPB will be changed significantly by the technology used in the CEP. Participants noted that there was far more information on the actual enemy situation available during the planning phase than there is in a conventional TOC. Therefore participants stated that the process was considerably streamlined. Participants also noted that there was no formal mission analysis brief, thus accounting for the "Changed" rating for the Briefing and Approval sub-step by test players. However, the MDMP sub-steps of Analyze Higher Mission, Analyze Brigade Order and Assess Risk were seen as "Unchanged." In particular, participants' ratings indicated that their analysis of the brigade mission and order were unchanged.

Course of Action Development. Only test players rated the Course of Action Development step itself as "Changed" (see Figure 6), but both test players and observers rated all sub-steps as "Unchanged." Although the majority of test players' responses indicated that the Course of Action Development step was "Changed," the modal response for all the sub-steps

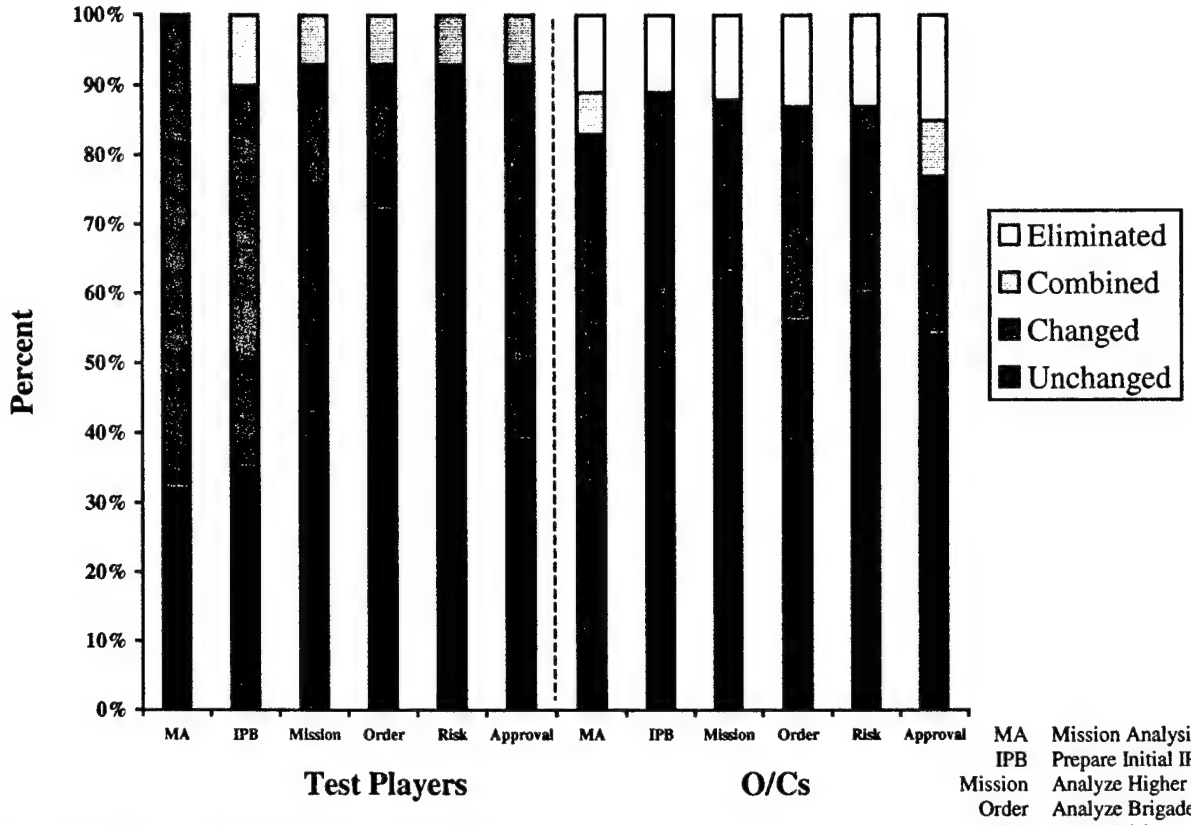


Figure 5. Responses to mission analysis.

MA	Mission Analysis
IPB	Prepare Initial IPB
Mission	Analyze Higher Order Mission
Order	Analyze Brigade Order
Risk	Assess Risk
Approval	Briefing and Approval

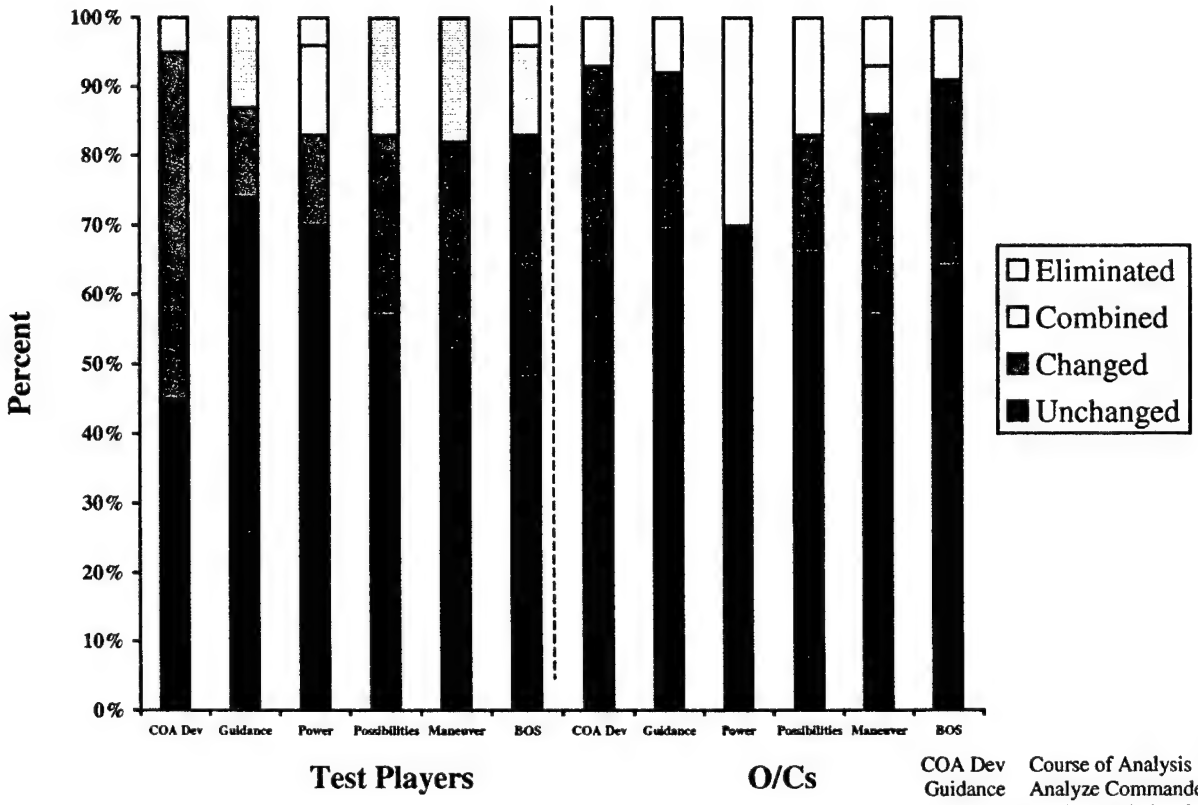


Figure 6. Responses to course of action development.

COA Dev	Course of Analysis Development
Guidance	Analyze Commander's Guidance
Power	Analyze Relative Combat Power
Possibilities	Generate Conceptual Possibilities
Maneuver	Develop Scheme of Maneuver
BOS	Incorporate All BOS

was "Unchanged." The pattern for observers was the same, but half the observers rated the step itself (i.e., Course of Action Development) as "Unchanged." Comments emphasized that while the tools provided a capability to develop effective courses of action, several battlefield operating systems were not well integrated.

Wargaming. Test players were somewhat more likely to rate Wargaming as "Changed" in the CEP than were observers (see Figure 7). A solid majority of test players' responses indicated that Wargaming was "Changed." However, of the six sub-steps, the modal response was "Unchanged" except for the sub-steps of Follow Wargaming Method and Record Results. For these two sub-steps the modal response was "Changed." For observers the modal response was "Unchanged" for the Wargaming step and all sub-steps except for Record Results. Here, the majority of responses was "Eliminated." Many comments noted that the wargaming method followed in the CEP was much abridged or less formal, which may account for the test player ratings of the wargaming method as "Changed." Other frequent comments referred to use of the Whiteboard and involvement of company commanders.

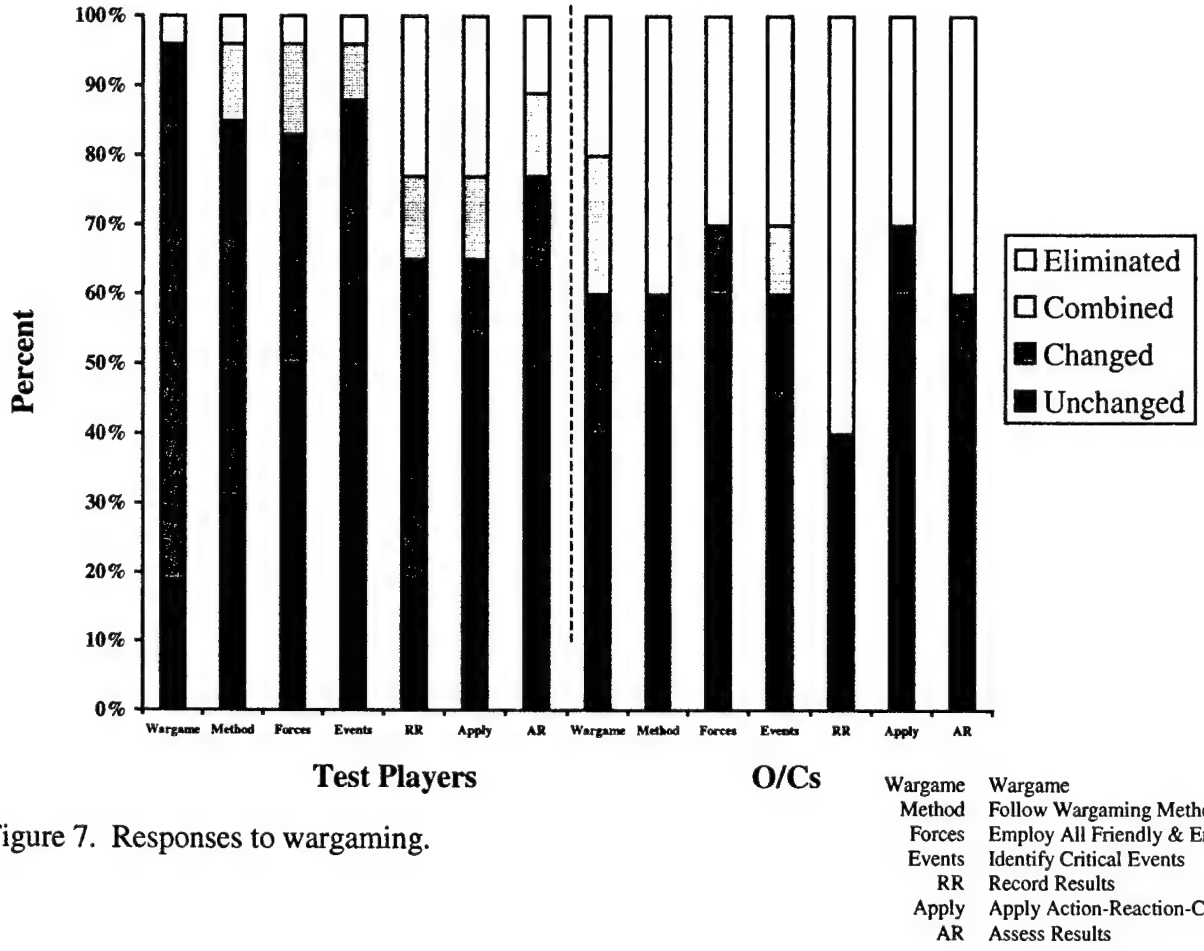


Figure 7. Responses to wargaming.

Wargame	Wargame
Method	Follow Wargaming Method
Forces	Employ All Friendly & Enemy Forces
Events	Identify Critical Events
RR	Record Results
Apply	Apply Action-Reaction-Counteraction
AR	Assess Results

Course of Action Comparison. Participants tended to see the step Course of Action Comparison as "Changed" (see Figure 8), but the sub-steps as "Unchanged." The modal response of all participants for the step of Course of Action Comparison was "Changed." Again,

however, the modal response for all participants was "Changed" for only one of the three sub-steps (Select Comparison Method). The modal response for both groups for the other two steps (Determine Decision Criteria and Weights and Record Results) was "Eliminated." The comments reflect these ratings. Numerous comments from participants stated that no formal process was used: no decision matrix, no formal criteria, no weighting criteria recorded, no decision brief. Several of the comments implied that these methods were unnecessary, as the solution was transparent.

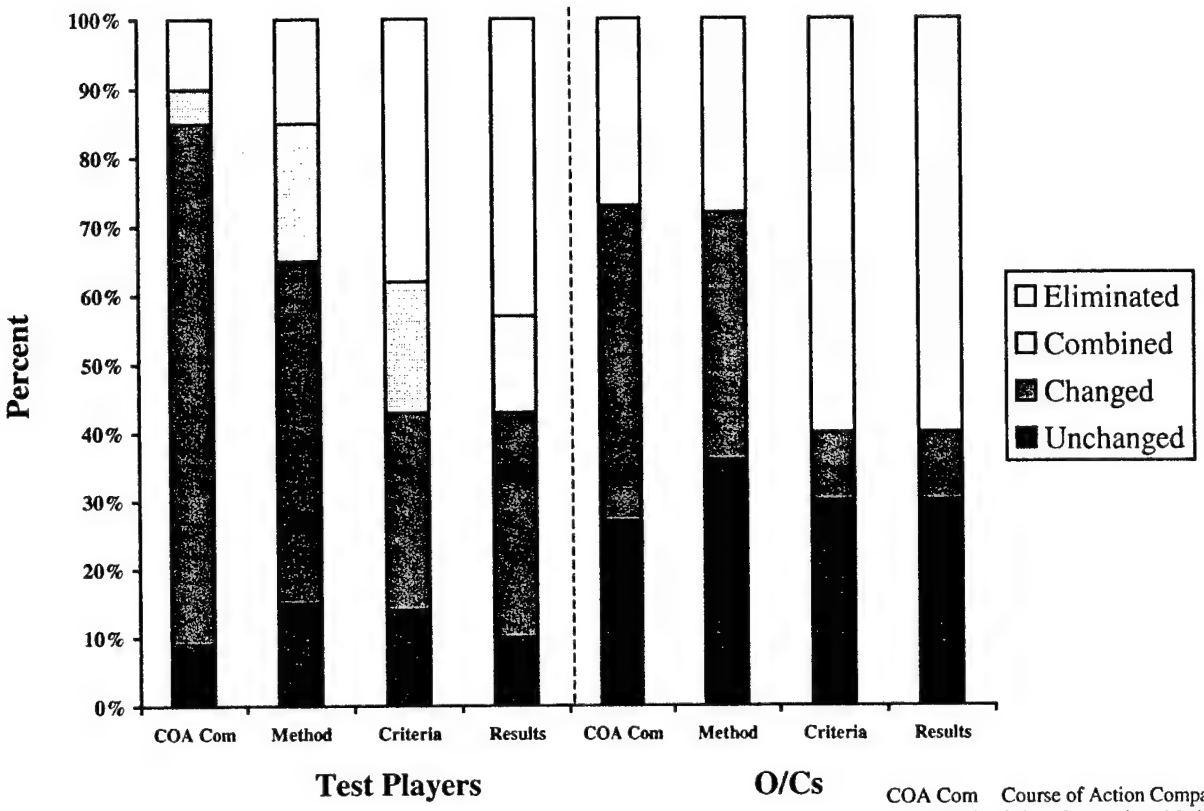


Figure 8. Responses to course of action comparison.

Orders Preparation. Participants tended to view the step Orders Preparation as "Unchanged" (see Figure 9). For Orders Preparation a majority of both test players' and observer ratings for both the step and, thereby, all sub-steps was "Unchanged." There were fewer comments concerning this step than any other steps. Comments described the digital nature of the battalion order as developing more quickly than a conventional order and as event driven.

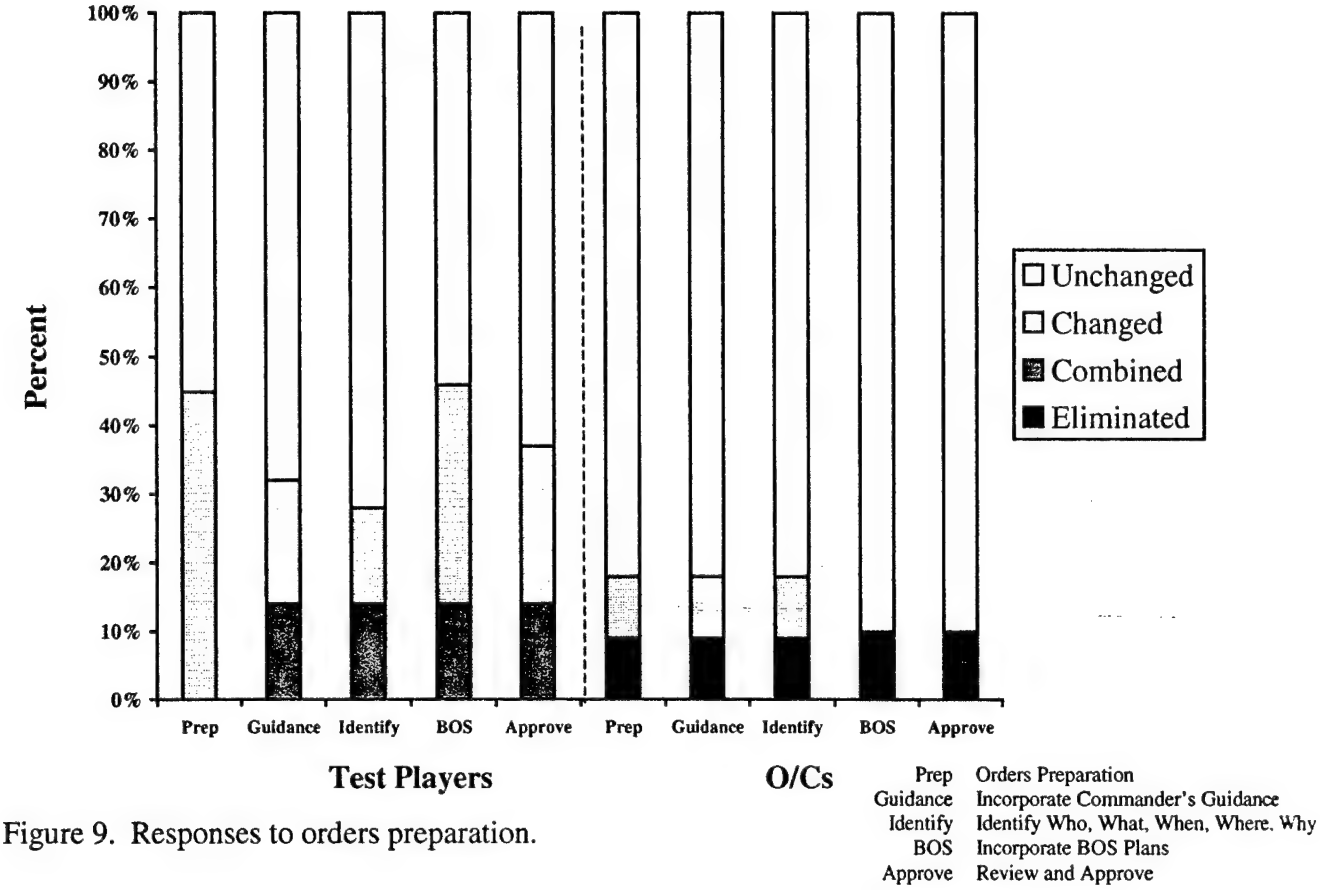


Figure 9. Responses to orders preparation.

Rehearsal. Participants mostly saw the step Rehearsal as "Unchanged" (see Figure 10). A majority of test players' responses for the step itself were "Changed." For observers, the preponderance of responses for the step were evenly divided between "Unchanged" and "Changed." However, for both test players and observers, a majority of responses for all sub-steps was "Unchanged." The fact that test players rated the step as "Changed" while rating all sub-steps as "Unchanged" may indicate a problem with the sensitivity of the questionnaire. A large number of comments stated that the rehearsal was conducted with company commanders via Whiteboard and radio. Other comments indicated that there was no formal decision support template. These comments reflect that the task remains the same, while techniques and procedures differ.

Mission Execution and Transition. Test players and observers appeared to differ concerning whether Mission Execution was "Changed" (see Figure 11). For test players, the majority response for the Mission Execution step of the MDMP was "Changed." However, for observers, the majority response was "Unchanged." Many comments referred to how indirect fires were handled in the CEP, indicating that the artillery BOS process was quite different in the digital environment. Another comment was that the commander's battlefield visualization was much greater during execution than in a conventional TOC. Other comments stressed the fact that less "up front" planning was necessary, since the staff could now more easily detect and react to changes in the situation.

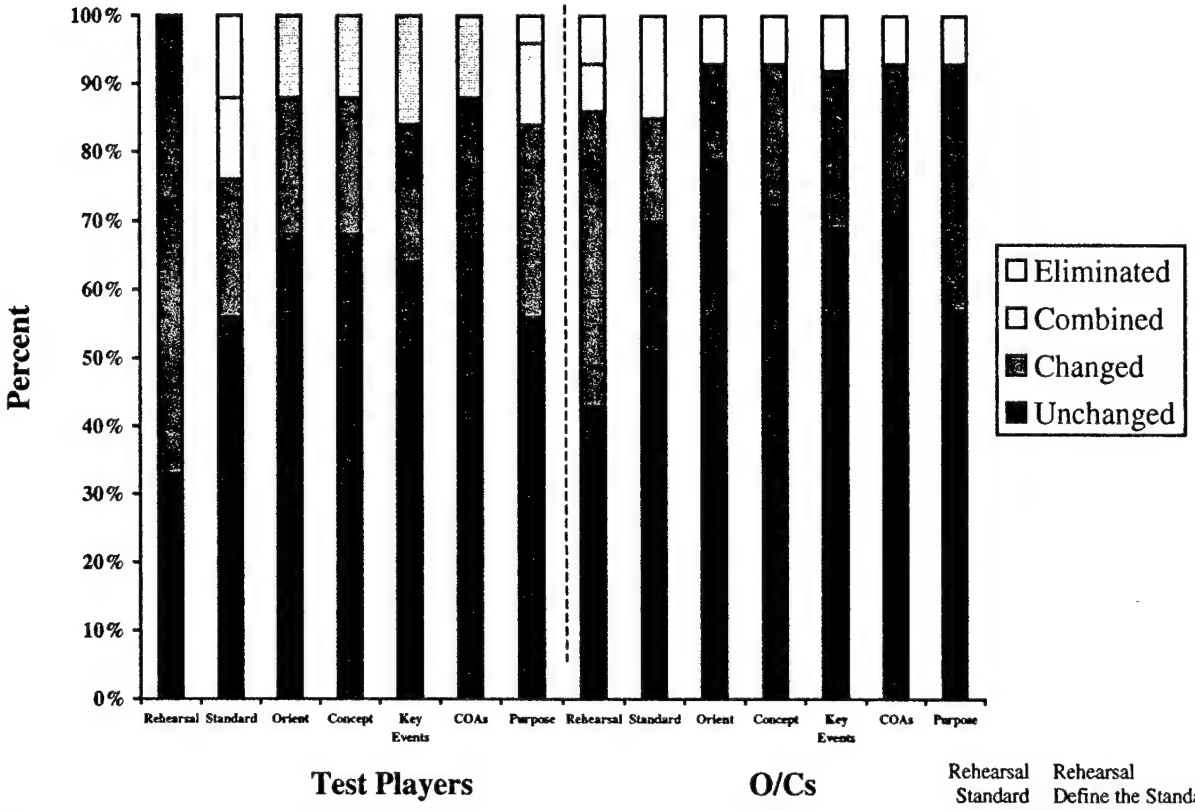
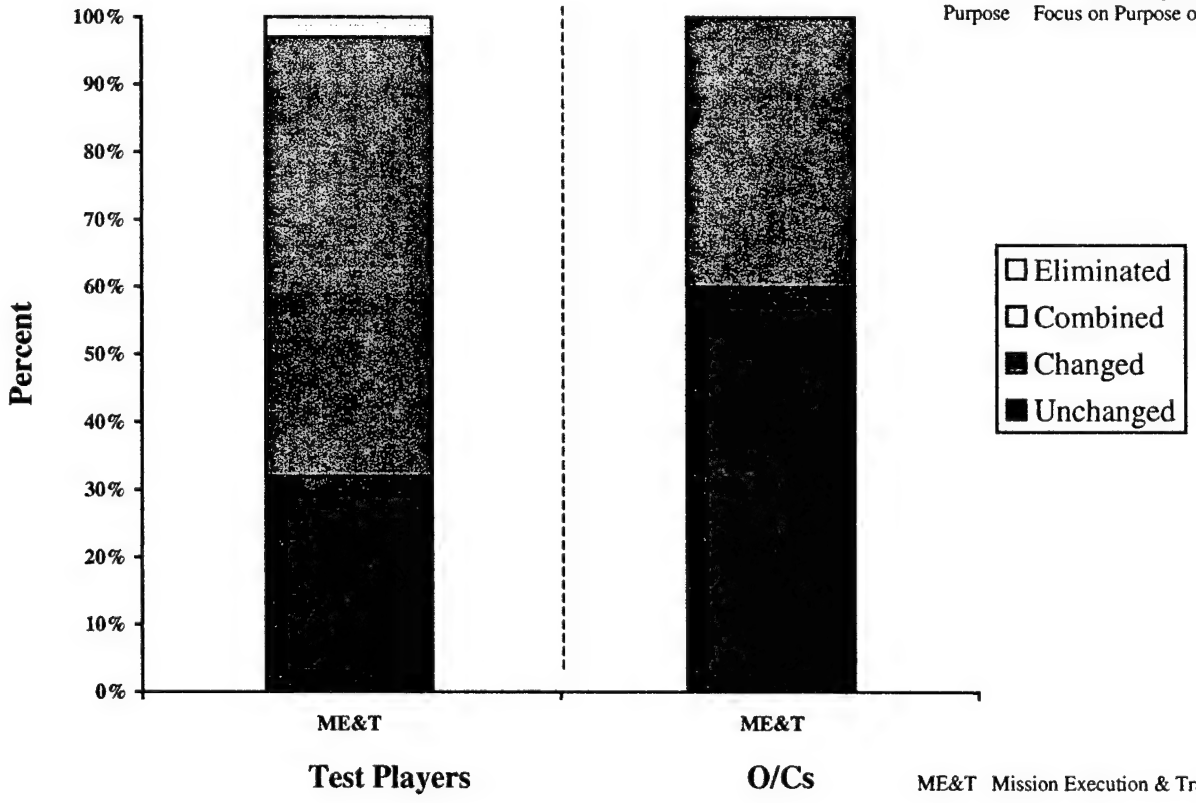


Figure 10. Responses to rehearsal.

Rehearsal	Rehearsal
Standard	Define the Standard
Orient	Orient Players to Terrain
Concept	Verbalize Concept of the Operation
Key Events	Select Key Events to Rehearse
COAs	Describe Enemy COAs
Purpose	Focus on Purpose of Rehearsal



ME&T Mission Execution & Transition

Figure 11. Responses to mission execution and transition.

Effectiveness and Efficiency Ratings

The mean observer ratings on effectiveness and efficiency appear uniformly lower than those of test players. For test players, ratings were slightly above "Moderately Efficient" or "Moderately Effective" (an example of the scales is given at Figure 12). For observers, ratings were at or slightly below "Moderately Efficient" or "Moderately Effective." Among test player ratings, relatively lower ratings were assigned for wargaming efficiency, and course of action comparison effectiveness and efficiency. Similarly, among observer ratings, relatively lower ratings were assigned for wargaming effectiveness and efficiency and course of action comparison effectiveness and efficiency.

MISSION ANALYSIS		
Inefficient	Moderately Efficient	Very Efficient
0	1	2
Ineffective	Moderately Effective	Very Effective
0	1	2

Figure 12. Efficiency and effectiveness rating.

Hot Wash Results

In the final hot wash, a version of the MDMP that reflects the digital capability of the C^4I systems was reviewed. This version was based on test players' experiences and inputs in the CEP (see Figure 13). The subsequent description of this digital MDMP is based on the hot wash comments of observers and test players, and not responses to any instrument designed by ARI. Initially, the brigade digital order was transmitted to the plans node, which in turn emailed the OPORD to the other three nodes. The commander then provided initial guidance to the Plans node for COA development and to the operations node for reconnaissance and surveillance planning. The plans node then conducted mission analysis followed by COA development, analysis and comparison (recommendation). Meanwhile the operations node developed and executed the reconnaissance and surveillance plan. Generally, only one COA, with embedded contingencies, was generated. The commander then modified the COA and wargamed it with the company commanders using the Whiteboard and radio communication. The Plans node eavesdropped on the wargaming session, and quickly modified the plan based on results of the session. The Plans node then transmitted the battalion OPORD via the Whiteboard to the commander, who then modified and issued the OPORD. The task force commander then rehearsed the order with company commanders, again via Whiteboard and radio.

Test players noted that "rehearsals" were more like a mission brief, perhaps because technical shortcomings limited test player interaction. However, the power of the tools was illustrated during the rehearsal of the final (Attack) test mission, where the PVD revealed a major change in the way enemy troops were deployed based a recent update via the sensors. The enemy operations officer in the commander's node called the change to the commander's attention, who then altered the plan immediately. The new plan was then executed.

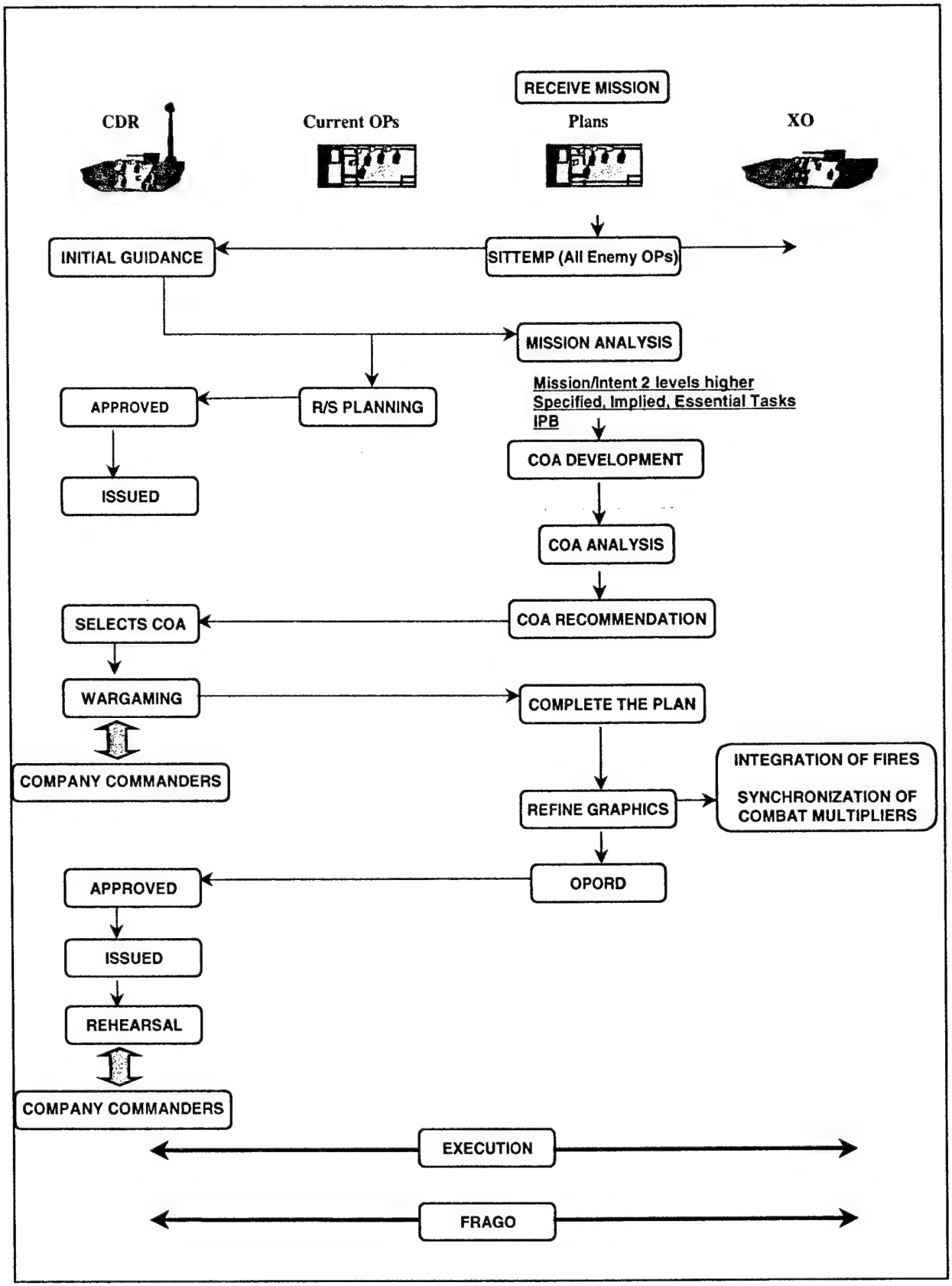


Figure 13. Decision making process for digital capability as outlined in hot wash.

The discrepancy of activity among nodes is readily apparent from Figure 13. Across all test missions, test players noted that the commander's node and operations node were most active in the mission execution phase. About half way through execution of the first two test missions, a new brigade mission (OPORD) was emailed to the plans node, starting the process over.

Discussion

This section discusses the CEP results on battle command information requirements and the MDMP. First, this discussion provides some probable explanations for some notable results reported on identifying and meeting information requirements. Then recommendations on how information requirements might be better met are considered in more detail. Discussion of the MDMP results summarizes and interprets results from the MDMP Questionnaire and test players' hot wash comments.

Information Requirements

Assessment

Overall, the results indicated that most of the component types of METT-T information included in the Information Requirements Questionnaire were regarded as required information. At the information component level, mean participants' ratings on information required ("Required" = 1.00) ranged from .47 for threat's Ability to Communicate, to .99 for Operations Overlay. Across components, at the METT-T factor level, enemy information received the lowest required mean rating at .79, and mission information received the highest at .91. Notable exceptions, from the overall pattern that most information components were rated as required, include selected component types of enemy information.

There are several probable reasons for such exceptions. Given the preliminary nature of these results, no conclusions will be made concerning information not required. Enemy information is almost always priority information, as indicated by the Commander's Critical Information Requirements (CCIR). Participants' high ratings on location, composition, and disposition components reflect the requirement for such enemy information. In contrast, lower ratings occurred on enemy components such as ability to communicate and ability to sustain. Why? Such ratings may indicate that current training does not adequately stress the impact of realistic communications, including degraded communications, on friendly and enemy capabilities. In addition, questionnaire and hot wash comments indicated that some participants had no idea how information on these enemy components might be obtained and provided. Participants' perceptions about what information might be feasible, therefore, may have tempered some requirement ratings. An alternative explanation is that the forward-edge of the battlefield role simulated by the test participants may direct warfighters' information requirements to more immediate threat aspects, such as enemy location and firepower rather than communication and sustainment. Future research efforts, therefore, might take a more precise approach to identifying and assessing information requirements by task and condition.

Overall, the results indicated that test participants' information requirements, as tested, were met or nearly met. At the information component level, mean participants' ratings on how well their information requirements were met ("Met" = 2.00) ranged from 1.54 for weather, to 2.33 for friendly location. Across components, at the METT-T factor level, terrain information received the lowest met mean rating at 1.80, and troop information received the highest at 1.99. Notably, none of the information components rated during the evaluation approached the level of "Exceeded" (= 3.0). These results suggest there is a substantial need for C^4I system improvements to better meet information requirements.

Finally, although the evaluation's lead issue addressed the commander's information requirements, these results were based on the participants' duty position, as played or observed, during the evaluation. Future efforts might assess the commander's information requirements more directly, to include the CCIR. For example, questionnaires might ask the commander to identify his CCIR and to have him and the other participants assess how well these CCIR were met. Future C^4I systems, however, may affect CCIR nature and process. These and related doctrine and tactics issues might be addressed in future efforts.

Recommendations

Participants' recommendations on how to improve C^4I systems to better identify and meet battle command information requirements are considered in this section. Table 5 provides a complete account of participant recommendations from the IR Questionnaire, by METT-T information component. These recommendations provide a fairly specific set of requirements for improving the C^4I systems used in the CEP. More generally, these recommendations may provide useful information for improving legacy C^4I systems as well.

Table 5

Recommendations on Information Requirements

Mission Component Recommendations on Information Requirements	
Warning Order	Comments on warning order information repeatedly stressed that a more compatible set of C^4I capabilities and products at brigade level are needed to provide required information. Recommendations for improving these brigade level products included a standardized format with more detail and the ability to manipulate the detail provided. With respect to standardized format, for example, one respondent stated "establish format and method to ensure completeness of data." In particular, respondents noted the need to provide more precise information that would inform sensor operators, such as unmanned aerial vehicle operators, with immediate areas of concern. More specifically, some respondents urged that sensor operators be issued a warning order. More generally, respondents also urged that received warning orders should include intelligence information on the unit's area of operation. With respect to manipulation, for example, one respondent stated "make it [a] matrix, pull out needed information." Another respondent stated "provide [the] computer the ability to break down higher order."
Operations Order	Comments on operations order information also stressed that a more compatible set of C^4I capabilities and products at brigade level are needed to provide required information. In particular, respondents urged that C^4I systems provide the ability to extract or parse those portions of a higher echelon order most pertinent to lower echelons. Test players and O/Cs urged a standardized format to better ensure that the detail missing from these products during the CEP was routinely included. A number of respondents also urged a wider dissemination of the brigade level operations order. For example, one respondent stated "why only [a] select few, shouldn't everybody in the XO's TOC receive?" Finally, several respondents seemed to question the requirement for the more traditional, analog format of a five paragraph operations order. Typical of such comments, one respondent stated "oral only if necessary." One rationale for such comments, provided by respondents, was that the digital operations overlay format that evolved during the course of the CEP provided much of an order's information in a more useful format.
Operations Overlay	Comments on operations overlay information again stressed that a more compatible set of C^4I capabilities and products at brigade level are needed to provide information. To facilitate visualization of the mission, respondents also recommended a standard library of icon symbology and more than one color to represent overlay content and/or type. The most recurrent, and possibly the most telling, comments on meeting mission information requirements centered on the need for a more integrated C^4I tool set to fuse information sources. In particular, respondents stressed that ancillary tools such as the Whiteboard must be combined with a dynamic map display. The recommendation to integrate all mission related information into dynamic map overlays and displays was strongly reinforced by both questionnaire and hot wash comments.

Table 5 (continued)

Commander's Intent	Comments on information requirements related to commander's intent stressed that C^4I capabilities should enable a clear delineation of priorities and end state. For example, several respondents requested a format that included more precise information on the priorities for unmanned aerial vehicle operators. Others requested more precise information on the commander's willingness to lose assets. A number of respondents cited that formats should provide a clear understanding of the intended end state of the mission. Generally, respondents' comments indicated their approval of the Whiteboard link that allowed the commander to depict and annotate a sketch of his intent to all test players.
Course of Action	Comments on requirements related to course of action information stressed that the CEP's C^4I capabilities did not provide a standardized format for situation templates or the ability to wargame courses of action. In particular, hot wash comments underscored the need for information formats to delineate and coordinate the sequence of actions. Numerous respondents stressed the need for a reconnaissance and surveillance plan to coordinate actions and delineate control. Similarly, company commanders repeatedly reported they understood the course of action in general, but did not clearly understand the sequence and interaction for company operations. A number of respondents requested more specific information on routes. For example, one respondent stated "did not use any routes just an area." Overall, respondents suggested a more continuous linkage for Whiteboard type communications to clarify and adjust activities during the course of operations.
Fragmentary Orders	Comments on information requirements related to fragmentary orders were limited. Some respondents suggested that fragmentary orders were not fully exercised during the CEP. Others stated that oral orders followed the initial operations order. Again numerous respondents commented that the information requirements related to fragmentary orders might be better met by providing a more continuous linkage for Whiteboard-type communications.
Enemy Component Recommendations on Information Requirements	
Location	Respondent comments stressed that the CEP simulation did not provide a comprehensive "read" on enemy location data. Numerous respondents noted that a more extensive feed from higher echelons might have provided the 80-90% solution on all enemy locations they had expected. In addition, many respondents complained that enemy location information was not adequately shared among test player stations. For example, they reported that UAV operator stations only displayed enemy locations detected by the UAV display in question. Finally, both questionnaire and hot wash comments suggested that future C^4I systems should dynamically link and match enemy situation templates to depicted enemy locations.
Composition	Comments on enemy composition cited the need for additional information on vehicle and unit types. For example, numerous respondents requested automatic identifiers for enemy air defense and logistic assets. Others noted that manual analysis and/or confirmation of composition types would still be needed and, therefore, future C^4I systems should at least provide operators a labeling capability to indicate composition.
Disposition	Comments on enemy disposition suggested that better information on enemy location and composition would greatly assist efforts to determine disposition.

Table 5 (continued)

Ability to See	Comments on enemy's ability to see were of two major types. Some respondents' noted the need for additional information such as graphic depiction of the "dead space" associated with enemy vehicles or icons should be provided, as required or on-call. Other respondents questioned the feasibility of the requirement. For example, one respondent said "don't know how you would get this information from current system." While future C^4I systems might provide various levels of information on the enemy's ability to see, the system used during the CEP provided at least one level. Test players routinely clicked on stationary friendly vehicle locations to obtain line-of-sight analyses on their ability to see from that location. Training might have stressed this same capability could be applied to stationary enemy icons to obtain information on the enemy's ability to see from a selected location.
Ability to Move	Comments on enemy's ability to move stressed the need for information on potential mobility corridors for enemy units, and estimates on enemy's rate of march. Numerous respondents stressed the need for more valid information on the enemy's ability to move. In part these comments pertain to invalid or unrealistic enemy movement that many respondents perceived during the CEP's simulation-based missions. On a more general level, such comments underscore the requirement stated by numerous respondents to ensure that the information provided by C^4I systems is not misleading or inaccurate.
Ability to Shoot	Comments on enemy's ability to shoot stressed the need for information on enemy weapon ranges. In particular, several respondents requested that C^4I systems should provide terrain-adjusted enemy weapon ranges. Numerous respondents stressed the need for more valid information on the enemy's ability to shoot.
Ability to Communicate	Comments on enemy's ability to communicate included various recommendations for better meeting this requirement. Respondents' requested information to identify vehicles with multiple antennas. Another respondent noted the need for information that tracked radio frequency and intensity. Other respondents requested information on estimated radio ranges adjusted for terrain, and connectivity between vehicles and units.
Ability to Sustain	Comments on enemy's ability to sustain raised many questions about how such information might be obtained and provided. Several respondents noted that basic information on enemy logistics status at the start of the mission might provide a basis for tracking and updating enemy sustainment. Generally, respondents stressed that mission design should entail combat service support (CSS) functions. Other respondents noted this requirement might surface with more extended mission operations. For example, one respondent noted "the fight never lasted long enough to strain CSS functions." Another respondent stated that he "never saw enemy supply trains."
Terrain Component Recommendations on Information Requirements	
Observation	Comments on terrain-based observation information requirements stressed that many of the terrain tools provided were not very effective. Several respondents were also concerned that the tools provided would not work in a non-desert environment with more challenging relief. And several respondents iterated the need for a better data base to support their requirements for observation.

Table 5 (continued)

Cover	Comments on terrain-based cover information requirements stressed many of the points noted on the observation component. In addition, due to the limited cover available in the area of operations used for the CEP, many respondents suggested they were not too concerned about such information and did not exercise some of the terrain tools available. Again, several respondents expressed the need for cover information in more challenging relief, but concerns about the accuracy of information that might be provided in such areas.
Concealment	Comments on terrain-based concealment information requirements stressed many of the points noted for observation and cover components. In general, respondents urged that more challenging relief be used in future efforts to better assess how well terrain related information requirements are met. Again, respondents stressed the need for accurate terrain data bases.
Obstacles	Comments stressed that obstacle information was a critical requirement for many military operations, including those conducted during the CEP. They also stressed that the C^4I information systems used during the CEP failed to provide or depict most of the information required on manmade obstacles. In addition, they urged that future trial scenarios should ensure that obstacle emplacement and deliberate-breaching tasks are required aspects of the operation.
Key Terrain	Comments on key terrain information requirements noted that the C^4I information systems used during the CEP provided no capability to explicitly identify or mark key terrain features. Numerous respondents expressed a belief that human analysis is required to accurately identify what terrain aspects or features are key. At a minimum, however, they recommended future systems should provide a means to label or mark key terrain. Finally, several respondents commented that key terrain markings would be useful for mission analysis and brief.
Approach Avenues	Comments stressed that the CEP C^4I capabilities did not support respondents' information requirements for approach avenues. At a minimum, these comments urged future systems should provide approved graphic symbols for approach avenues and the ability to annotate and delete those graphics as required. In addition, respondents suggested that future systems should be able to analyze and identify approach avenues automatically, and that this ability should adapt to different unit sizes.
Weather	Comments on weather information requirements noted that weather was not a factor during the operations simulated during the CEP. Scenario design did not stress weather effects and only clear daylight conditions were simulated. Several respondents stated there should be a requirement for a weather report as part of the brigade operations order. One respondent noted that Doppler-type radar updates on weather conditions might be helpful in future operational settings.
Troop Component Recommendations on Information Requirements	
Location	Comments on improving troop location information were quite limited which seemed consistent with their relatively higher ratings on this information component. For example, several respondents stated "maintain" the level of information provided. Numerous respondents urged a more distinctive color scheme for friendly icons and symbols to ease tracking of friendly troop locations. Several respondents also noted that the location of command vehicles should be provided on their tactical displays.

Table 5 (continued)

Organization	Comments on improving troop organization information stressed the need for labels indicating unit affiliations. Several respondents indicated that unit organization should be part of the operations order. Recall, that under mission information requirements numerous respondents urged a standardized format for digital operations orders. Comments on organization requirements suggested that such information should be part of that standardized format. In addition, several respondents noted difficulty in identifying separate units.
Ability to See	Comments on the friendly's ability to see were quite limited. One respondent noted that this ability might be improved by providing a higher magnification for terrain data base manipulation.
Ability to Move	Comments on the friendly's ability to move stressed the need for information to improve test players' understanding of trafficability. Several respondents again cited the need for more automated information to identify avenues of approach and mobility corridors. One respondent requested a capability that indicated current range of a vehicle, based on fuel consumed. Finally, one respondent noted that even with more automated information on the unit's ability to move, "company commanders [still] have to pave the way."
Ability to Shoot	Comments on the friendly's ability to shoot provided a variety of suggestions for better meeting this information requirement. The most frequent request was the ability to directly observe firings by direct and indirect systems on the tactical display, a capability sometimes called "engagement updates." Respondents also noted that their information systems should indicate "dead space" in relation to weapon systems' capability.
Ability to Communicate	Comments on the friendly's ability to communicate noted that test players had no ability to analyze radio ranges or to assess their need to retransmit. Several respondents stressed the need for more immediate communication function, particularly for electronic mail messages. In general, respondents noted that the simulation, as conducted, resulted in "broken" communications and that future efforts should improve on this problem.
Ability to Sustain	Comments on the friendly's ability to sustain forcefully stressed that combat service support information is a critical information requirement that was not addressed during the CEP. Their comments also emphasized that the inclusion of logistics was essential to CEP efforts to better identify and meet the information requirements related to sustaining friendly operations.
Time Component Recommendations on Information Requirements	
Plan	Comments on time to plan from many respondents stressed that no time lines for task force operations were established during the CEP missions. Related comments noted that the CEP's C^4I systems provided no capability to analyze time requirements or to monitor progress in relation to a time line. Several respondents stated there was more than adequate time to plan, but others stressed that the lack of detail in task force planning underestimated planning requirements. Comments on the need for more detailed planning cited the requirement for more extended combined arms planning across battlefield operating systems, more detailed information from higher echelons, and more time for lower echelon planning at company and platoon levels.

Table 5 (continued)

Wargame	Comments on time to wargame were quite mixed. Some respondents stated there was too much time allowed for this, but another stated that wargaming was "quite rushed." At least one explanation for these apparent discrepancies might be some confusion about the nature of wargaming. As one respondent stated "the type and function of wargame were unclear." Another explanation might be duty level differences. In particular, lower level company commanders commented on the need to maintain adequate planning time. Both questionnaire and hot wash comments strongly stressed that future C^4I systems should provide an automated capability to wargame potential courses of action.
Prepare	Comments on time to prepare were as mixed as comments on time to plan. Notably, they varied from "too much time allowed" to "need more time." Again differences in duty level might explain some of this variation with lower level company commanders requesting more time. For example, one respondent stated "need more time before executing for company commander to brief platoon leaders." Similarly, another respondent urged that future efforts should "replicate preparation at platoon and crew level." In addition, several respondents repeated the need for an established time line.
Rehearse	Comments on time to rehearse primarily stressed the need for more time to rehearse. Again, company commanders stressed the need to rehearse with their platoon leaders. Several other respondents noted that rehearsals were conducted at Task Force level only. In addition, questionnaire and hot wash comments noted that future C^4I systems should provide some automated capability for the unit to rehearse.
Execute	Comments on time to execute primarily stressed that future C^4I systems should provide supporting automated capabilities. Both questionnaire and hot wash comments identified an unmet requirement for a decision point tool. Respondents requested a capability to input and display decision points on the tactical display. In addition, numerous respondents requested that displayed decision points should be coupled with an automated check and feedback before designated decision points were reached.
Synch Execute	Comments on time to synch execute also stressed that future C^4I systems should provide supporting automated capabilities. Both questionnaire and hot wash comments cited the need for a digital version of a synchronization matrix. Suggestions on the format for this digital synchronization matrix varied considerably, but numerous respondents stressed the need for a dynamic format with automated updates during the course of execution. Others suggested that a digital synchronization matrix should support alternate formats to include both table and figure presentations of the same information.

Overall, participants' comments provided many important recommendations to better meet battle command information requirements. Table 6 provides a summary of these recommendations, by METT-T factor. This table represents a summary of the key recommendations from Table 5 and the IR Questionnaire, and participant recommendations from the hot wash sessions. Based primarily on participant comments, the Table 6 items differentiate recommendations directed at C^4I system improvement versus scenario improvement. The scenario improvement recommendations relate directly to the scenarios used during the CEP. These recommendations should provide useful information for design and refinement of scenarios for future efforts.

A dominant theme across recommendations was the need to more effectively integrate the information required and provided. Such comments stressed that a dynamic map display should be the primary locus for visualizing the battlefield. Participants urged that all information tools directly link to a dynamic map display. In addition, they advocated graphic formats for required information, whenever possible, with graphic links to supporting text information and data bases, as required.

Table 6

Recommendations on Meeting Battle Command Information Requirements by METT-T Factor

Factor	Information Requirement Recommendations
Mission	Compatible Information Systems and Products at Brigade More Detailed Information at Company and Platoon Electronic Aids for Wargaming Automated Situation Template All Information Tools Integrated to Dynamic Map Display
Enemy	Current Enemy Situation Linked to Enemy Templates More Detailed Information on Composition Battle Damage Assessment Updates Terrain-Adjusted Weapon Ranges More Realistic Movement and Firing*
Terrain	More Accurate Data Bases with Better Resolution Obstacle Emplacement and Breach Symbology Smoke Effects Calculated and Depicted Estimated Rate of March Mobility Corridors Analyzed and Depicted
Troops	Combined Arms Operations* Sustainment Conditions Required* Proactive Brigade Assets for "Shared Box"* Reconnaissance & Surveillance Plan Unmanned Aerial Vehicle Coordination
Time	More Detailed Information from Brigade* Time Line Monitor and Feedback Company and Platoon Rehearsals* Synchronization Matrix Tool with Table and Figure Formats Decision Point Display and Checks

* Note. Recommendations more related to improving scenarios than C^4I systems.

Recommendations for a dynamic map display also reflect participants' concerns about information accuracy and currency. Comments on linking the current enemy situation to enemy templates, for example, stressed that C^4I displays should maintain a current depiction of the enemy situation. Participants urged that future systems continuously match and assess detected vs. projected enemy data. Hot wash discussion noted that, in the future, threat operations may not match contemporary doctrinal "templates." However, they noted that the intelligence preparation of the battlefield process would still entail the projection of threat courses of action. Participants recommended that C^4I systems routinely assess such projections against current enemy data, and graphically highlight identified discrepancies.

Participants' comments on mission-based information also stressed that a more compatible set of C^4I capabilities and products at brigade are needed to provide required information. Recommendations for improving these brigade-level products included a standardized format with more detail and the ability to manipulate readily the detail provided. Participants emphasized that compatible C^4I systems should achieve a truly shared operational area ("box") for brigade and battalion level units. The battalion commander stated this shared box should result in proactive vs. reactive synchronization of brigade and above assets. Also, it would substantially reduce the need for information and support requests between echelons and allow the higher echelon to match resources to priorities. Participants' comments on system improvements also included many human factors aspects such as color and symbol codes, e-mail prompts and replies, more precise and easier input devices, standardized formats and products, information data bases, and job aids.

Overall, the findings on information requirements met provide an empirical basis for directing improvements in future C^4I systems. Lower ratings indicating unmet requirements provide one basis for improvement priority. Notably, these ratings pertain only to information components previously rated as "Required" by a participant. Ratings that identified information requirements provide another basis for improvement priority. A weighted coupling of both met and identified ratings might also be used for the same purpose.

Participants also stressed the need for expanded operational evaluations to better identify and assess C^4I-based information requirements. Their comments on terrain information requirements stressed that future evaluations should use more challenging relief and varied operational settings. In addition, participants stated that more informative assessments should entail continuous operations, combined arms operations, futuristic scenarios and capabilities for friendly and threat forces.

Predictably, the CEP evaluation raised rather than resolved many important issues related to doctrine, tactics, techniques and procedures. For example, participants stressed that proponents of future C^4I systems should not expect such systems will supplant the expertise required for visualizing the battlefield. Soldiers should always be able to assess the accuracy and quality of information provided by an automated information system. Exposure to anticipated C^4I capabilities triggered participants' concerns about information verification and human decision making. Rather than concerns about too much information, participants stressed information access. The evaluation's effort to expedite plan and prepare phases may have prompted participants' concerns about information restrictions, particularly the filtering of

information through traditional communications channels or networks. In sum, the evaluation's findings indicate the potential impact of future C^4I systems on doctrine, tactics and procedures, and especially information requirements, is extensive but largely unknown.

MDMP

MDMP Step Results

There were few major changes reported by participants concerning the MDMP. Overall, test players appeared more likely to rate MDMP steps as "Changed" than were observers. However, both test players and observers rated most sub-steps as "Unchanged." No steps or sub-steps had a modal response of "Combined," and only two sub-steps of COA comparison had a modal response of "Eliminated." This, along with the questionnaire comments, suggested minimal changes in the MDMP during the CEP. Many questionnaire comments stress that the MDMP steps were performed in a less formal, more streamlined manner. Nonetheless, the steps were still performed.

There are cogent reasons for the lack of major changes in the MDMP in this CEP. The digital orders provided by brigade did not yet take full advantage of the C^4I systems capabilities. Therefore, the initial steps of mission analysis and course of action development may have proceeded along more traditional lines than if the orders enabled an integrated pictorial representation of the mission. Secondly, the test players lacked digital experience and were provided with no digital doctrine. Thus it is to be expected that they would feel more comfortable with familiar doctrine and procedures rather than invent new doctrine and procedures.

The COA comparison step was the one where most change was reported. Since only one COA was developed for the most part, a detailed comparison between COA was obviated. Also, the common picture of friendly and enemy provided by the C^4I systems tended to make the choice of COA fairly obvious, as indicated by several participant comments.

Effectiveness and Efficiency Results

Effectiveness and efficiency findings paralleled those of MDMP step ratings. The effectiveness and efficiency ratings from all participants centered around "Moderately Effective" or "Moderately Efficient." Ratings however, were especially low for the steps of Wargaming and Course of Action Comparison. This makes sense, since there was only one real COA developed. Thus a formal comparison to other COAs, with an elaborate decision process, was unnecessary.

Hot Wash Results

Hot wash results again showed all MDMP steps being performed, albeit some were now performed concurrently at different levels. For example, the OPORD was wargamed with company commanders and simultaneously modified by the plans node, rather than lock-step or sequential. The main finding might be that some steps such as wargaming, course of action

comparison, and rehearsal can be performed in a more streamlined, faster, less formal manner with the capabilities provided in the CEP. Test players reported that their ability to react to changes on the battlefield was substantially improved by the tools provided in the CEP.

Conclusions

This section provides conclusions on the results obtained. It also provides more extended recommendations on how to improve methods for assessing battle command information requirements and military decision making. In particular, these conclusions attempt to leverage the power of digital technologies, such as C^4I systems, to improve assessment methods.

More General Method Issues

Method improvements for assessing battle command information requirements and military decision making entail more general CEP evaluation issues such as test scenario development, training, and test design. These broader method issues are briefly described, but addressed in detail elsewhere (Elliott et al., 1998).

Scenario design is critical to improved measurement methods. Information requirements and decision making are highly dependent upon task context and the battlefield situations that comprise the test scenario or mission. Terrain factors, for example, impact information requirements significantly. This evaluation relied on relatively sterile desert terrain, but such terrain is not the only type mounted forces may encounter. Future efforts should include other potential conflict areas such as inhabited and forested locations. Task context alters information requirements and decision making processes across scenarios, even within a scenario. The CCIR might change repeatedly during a mission on a dynamic, unpredictable battlefield. Also, rapidly changing scenarios would require more rapid decision making and likely require a modified decision making process. Accordingly, participants urged that future evaluations employ robust and representative mission settings for more valid findings.

Training is also key to improved assessment. Participants should possess needed skills: fundamental combat skills for assigned duty positions, basic C^4I operator skills, and the ability to integrate combat and computer skills in a warfighting environment. Ideally, training would also address higher-order decision making skills, requiring test players to understand the *possibilities* of a C^4I system for mission accomplishment. As indicated in the discussion of evaluation results, participants were not fully aware of all the informational capabilities provided by their C^4I systems at the individual or collective level (e.g., enemy's ability to see). Enabling participants to use the C^4I system to obtain an integrated representation of the battlefield could likely further streamline the decision making process. Providing improved training, urged by participants, is needed to reduce measurement error and obtain a more valid assessment of how well information requirements are met and the extent to which decision making processes are changed.

Finally, test design for the evaluation should directly map measurement methods to evaluation purpose and issues. Design challenges include the fact that concepts such as battle command are not well defined from an operational measurement perspective. Notably, the

exploratory nature of the CEP investigation was consistent with evaluation schedule and resources that precluded multiple and more exacting samples from intact participant units with conventional and C^4I system collective expertise.

Future test designs, however, should capitalize on lessons learned during this evaluation to assess information requirements and decision making. Test designs should also capitalize on prior C^4I system evaluations, particularly the Army's AWEs. Virtual simulation, for example, affords many tools for exacting control over complex test designs (Elliott, Sanders, & Quinkert, 1996). In addition, formative evaluation methods for improving a system should be applied before summative evaluations are conducted (Lickteig, 1996).

Information Requirements

Results

The results indicated that most of the component types of METT-T information included in the Information Requirements Questionnaire were regarded as required information. Notable exceptions from the overall pattern include selected component types of enemy information. Given the preliminary nature of these results, however, no conclusions should be made concerning information not required. Future research efforts, therefore, might take a more precise approach to identifying and assessing information requirements by task and condition. This approach is discussed in Lickteig (1996). Overall, the results indicated that test participants' information requirements, as tested, were met or nearly met. These results also suggest, however, there is a substantial need for C^4I system improvements to better meet information requirements.

Method Improvements

Approach. Defining the domain and content of user information requirements is an essential issue to improving measurement methods for C^4I-based operations. Recall, the lead research issue for the evaluation specified a METT-T approach for assessing information requirements. However, other informational structures for defining combatants' information domain might be used such as tasks, functions or battlefield operating systems. Strategies for restricting the domain of interest might also be used. One strategy for limiting the domain might target the information required for selected processes, products, or outcomes related to unit performance. Another strategy might be to address a requirement subset, such as the CCIR.

While future research efforts might carefully consider the tradeoffs associated with alternate informational domain structures, there are important reasons why the METT-T approach for defining and assessing user information requirements is useful. For instance, the METT-T organization of battlefield information is a fundamental heuristic of Army training and doctrine. Also, from an evaluation and training feedback perspective, the representation and manipulation of METT-T information on a C^4I display provides a tractable and meaningful basis for assessing information requirements (Lickteig & Throne, in preparation). The following sections will discuss how METT-T supports the development and use of manual and instrumented measures for assessing information requirements and use.

Manual Measures. Only manual measures were used during the evaluation to identify information requirements and assess how well those requirements were met. A lesson learned from this evaluation is that both manual and instrumented measures should be used for information requirements assessment. Lessons learned from this evaluation and related research efforts for method improvements are considered for manual measures, and then for instrumented measures.

A general lesson reinforced by the evaluation is that methods for identifying and assessing information requirements are best embedded in task context (Cooke, 1994). Methods for identifying information requirements during task performance, without becoming disruptive, might be used (Cooke, 1994). Often called process tracing, such methods include manual protocols of participant or expert observer verbalizations and/or actions to request, access, use, and provide information as tasks are performed during a mission. An alternate method is to elicit the same types of information during a "simulated" mission rather than actual missions to reduce task interference.

Another lesson reinforced by the evaluation is that the design of manual measures should match method specificity and participants' experience. In the original version of the Information Requirements Questionnaire participants were asked to assess their information requirements at an overall METT-T factor level. One reason for that approach was to reduce participants' workload by limiting the number of items to be assessed (5 factors vs. 34 components). As the informational components underlying each factor had not yet been assessed, however, this item was too general and abstract. Measure design for exploratory research should match the participants' actual evaluation experience. One strategy for matching test design to test experience is the use of more structured test scenarios (Campbell, Campbell, Sanders, Flynn, & Myers, 1995).

A related concern is that information requirements are a multidimensional issue. A C^4I system may do a poor job of providing information requirements if it does not provide the information, if it requires the user to perform too much work to extract the information, or if it does not provide the information in a timely manner. The IR Questionnaire focused primarily on identifying *what* information was required. In the future, assessment methods should also address the workload associated with the information provided and not provided, to include information overload. And methods should also address the usefulness of the information provided, to include accuracy, clarity, completeness, and timeliness. For a more comprehensive set of method recommendations for assessing C^4I information requirements see Lickteig and Throne (in preparation).

In addition, the category of "exceeded" information requirements raises several concerns. First, the category may introduce ambiguity. Its selection might indicate a favorable response such as the C^4I system surpassed the rating of "met," or a negative response such as the C^4I systems provided too much information. Second, the category may be inappropriate for requirement specification. Only the Army goal of meeting information requirements is clearly justified. For the CEP results reported, readers are reminded that frequency distributions for each response category are available (Elliott et al., 1998). For future efforts, evaluators might avoid use of the "exceeded" category.

Finally, manual measures should not overload participants. In addition to the Information Requirements Questionnaire, participants were asked to complete, sometimes repeatedly, manual measures addressing the military decision making process, C^4I tools, multifunctional roles, training and experience requirements, workload, and information significance and structure (Elliott et al., 1998). Test designers should carefully weigh participants' workload across all proposed manual measures, and then develop and impose a test design that avoids overloading participants. One strategy for improving manual measurement methods and reducing participants' workload is a reliance on complementary instrumented measures.

Instrumented Measures. The CEP evaluation initiated instrumentation of the C^4I systems to provide automated measurement methods. Instrumented data from the initial evaluation was not analyzed due to technical and procedural limitations. Future research efforts, however, should capitalize on the instrumentation investment made by the MBBL and test bed facility. This section will focus on the potential contribution of C^4I instrumented measures for identifying and assessing information requirements.

A composite database of the elements depicted on the tactical display by source and path represents a measurable product achieved through collaborative information processing and management. This database provides a quantifiable link between the informational requirements of the user and the informational capabilities of the tactical display. It also provides a tractable link for identifying and assessing the information required, available, and used.

An indirect, but telling, measure of information utilization is visual access. Information available in a system is not always visible to the user. Although troop and enemy location information was uniformly available to all participants in the CEP, visual access to that information was determined by the map area currently depicted on each participant's C^4I display. New or updated enemy locations in areas not currently visible on their tactical display might go undetected. Therefore, the CEP's C^4I instrumentation was designed to record all information depicted on the participant's tactical display, and the precise area or "window" of the battlefield situation visible to the participant at any time. Assessing visual access to key information updates, such as priority intelligence requirements, should be fairly straightforward. The instrumentation can automatically track the exact time any intelligence update is first available on a C^4I system, and any delay before that update's icon becomes visible in any participant's display window.

A more direct measure of information requirements and use is an automated log of human-computer interactions. Such logs provide a relatively complete record or dialog of the information exchanges between the user and the computer, the participant and the C^4I system. Several examples of how this log information might provide useful instrumented measures are next described, based on the instrumentation developed for the initial CEP's C^4I systems.

When participants wanted more detailed information on troop and enemy units, they manually accessed and called-up this information to their C^4I displays. The log recorded the information requested (e.g., icon selected) and provided (report content). Related log measures include manipulation of the tactical map area displayed (e.g., pan, scroll, and zoom) and terrain

analysis. Instrumented measures from such log data can help identify information requirements and assess how well those requirements were met.

Direct measures of information requirements are possible when C^4I systems allow users to preset their information requests. The C^4I systems for future CEPs will allow participants to specify their priority information requirements, as a result of participants' recommendations during the initial evaluation. The C^4I system will then track and alert the user when the designated activity or status change occurs. A log of related human-computer interactions, therefore, should provide an automated set of participant defined information requirements, a record of how and when these requirements were met, and indicators of how and when that information was used based on participant reaction to that information.

In summary, automated logs of human computer interaction on C^4I systems provide a variety of instrumented measures for identifying and assessing information requirements. Logs on information requests and provisions, in particular, provide very direct measures. Measures can be tabulated at the individual level or compiled at any desired collective level. Interactions are automatically time-stamped to the simulated test scenario to determine or recreate the task context at the time of occurrence.

MDMP

Results

Since there was no comparison (control) group, it is impossible to definitively state whether the decision making process in the CEP was more effective and efficient than the current MDMP. However, it appeared that the MDMP used in the CEP was marginally more effective and efficient than the current MDMP in a conventional TOC. No steps were combined or eliminated; but several steps were performed in a more streamlined, faster and less formal manner than the current MDMP. Reaction to battlefield events during planning, preparing and execution was improved, according to test player comments. These findings are not unique. Elliot et al. (1996) report similar results on training lessons learned from the Army Warfighting Experiment Focused Dispatch. During Focused Dispatch, conventional doctrinal materials for the MDMP were available, but not their digital counterparts. The Task Force personnel in Focused Dispatch, as in the CEP, were creating new decision making tactics, techniques and procedures during the AWE. In the absence of new doctrine, participants fall back on old doctrine. Therefore, the lack of dramatic change in the MDMP during the CEP was not surprising.

Method Improvements

Approach. Different approaches could be used for measuring changes in the decision making process. The MDMP is the doctrinally approved method for staffs to operate under in the conventional environment (FM 101-5 [Department of the Army, 1997]). Since the issue in this research concerned changes to an existing decision making process (MDMP), the MDMP was used as the baseline and changes to it were assessed. Future C^4I environments will necessitate commanders to operate in much faster response cycles (decision-execution

timeframes) and nearly continuous option development and analysis (Alberts, 1995). The current, cumbersome, MDMP is almost certainly not the correct doctrine for such environments. Therefore in future efforts one might wish to be more open-ended about what decision making process is, or should be, used.

Manual Measures. Test players or observers could simply be asked to list, in order, steps the staff went through in making decisions. Perhaps methods such as thinking aloud or structured interviews would be used to help construct the decision making steps. These steps could be content-analyzed with the goal of developing a reasonable number of categories (e.g., 12 or less, perhaps including a miscellaneous category for low frequency responses). For instance responses like "determined mission requirements" and "analyzed what needed to be done to fulfill higher headquarters mission" would each be categorized as "mission analysis." Then each response could be assigned to one of the categories. Finally, a two-dimensional chart could be developed, with step number (i.e., one through n) as the rows and category as the columns. Cells would contain the number of times a given category was reported for a given step. Hopefully one process, or a few discrete possible decision making processes, would emerge. A way of adding some structure to this open-ended method would be to ask participants to choose among existing categories or steps. In addition to the MDMP, steps from research such as Klein and Crandall's (1996) Recognition Primed Decision (RPD) model and Deckert, Entin, Entin, MacMillan and Serfaty's (1994) work on expert military decision makers could be provided for participants or observers to choose from. The same two-dimensional table of step number by category could be constructed. Both variants have the advantage of allowing participants to describe their own decision making process, rather than confirm or reject a process provided a priori.

Instrumented Measures. While instrumented measures will not likely yield a decision making process, they could be useful in measuring its effectiveness and efficiency. A protocol could be designed for some subject matter expert, such as the battle master to enter electronic "flags" into the system when certain events occurred. Some possible events to be "flagged" could be: brigade OPORD issued; battalion OPORD issued; battalion OPORD execution begun; brigade fragmentary order (FRAGO) 1; battalion FRAGO 1; enemy COA change 1; battalion FRAGO 2. Time between brigade and battalion OPORD reflects planning time. Time between battalion OPORD and execution reflects preparation time. Time between brigade and battalion FRAGOs, as well as time between enemy changing COA and battalion FRAGO reflects the "reaction time" of the staff to unanticipated actions. These times would have to be compared to a "standard" or to those of a control group to operationally define changes in effectiveness or efficiency of the decision making process. One current standard, which may or may not be applicable to future staffs, is that the higher headquarters (e.g., battalion) use only one third of time available for planning, leaving two thirds of the available time for the subordinate unit (e.g., company team).

Summary

The methods and results reported for this initial CEP provide a preliminary baseline for assessing information requirements and military decision making in a futuristic operating environment. The results are in no way definitive, but they provide a benchmark for future CEPs

and related efforts. The results also provide many valuable suggestions for both C^4I system and evaluation improvements. Despite CEP design and execution limitations, the value of the results is underscored by their origin. The active duty CEP test players were immersed for two weeks in a challenging but powerful operational environment. The CEP's battle command reorganization and C^4I capabilities provided all participants and the Army a unique opportunity to explore information age frontiers and glean future lessons that bear on current issues.

The research design and methods used during the CEP were limited, but provide a useful "strawman" for future improvements (Elliott et al., 1998). General limitations for scenarios, training and test design were noted and recommendations made. Specific limitations to the manual measures developed and used to assess information requirements and military decision making were also described. Recommendations to improve these measures included: a METT-T structure for determining information requirements, and the applicability of the MDMP in a real-time information environment. Improvement recommendations for manual measures were also considered to include the timing and scope of assessment and participants' workload. Finally, the potential of instrumented C^4I systems to reduce participants' workload and increase measurement scope and precision of evaluation was encouraged for future endeavors.

References

Alberts, D. (1995). The future of command and control with DBK (pp 67-88). In S. E. Johnson & M. C. Libicki (Eds.) Dominant battlespace knowledge. Washington, D.C.: National Defense University.

Campbell, H., Campbell, R. C., Sanders, J. J., Flynn, M. R., & Myers, W. E. (1995). Methodology for the development of structured simulation-based training (ARI Research Product 95-08). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Cooke, N. J. (1994). Varieties of knowledge elicitation techniques. International Journal of Human-Computer Studies, 41, 801-849.

Deckert, J. C., Entin, E. B., Entin, E. E., MacMillan, J., & Serfaty D. (1994). Military command decision-making expertise: Final report. Alphatech, Inc., TR-631.

Department of the Army (1997). Field Manual 101-5, Staff Organization and Operations. Washington, DC: Headquarters, Department of the Army.

Elliott, G. S., Sanders, W. R., & Quinkert, K. A. (1996). Training in a digitized battalion task force: Lessons learned and implications for future training (ARI Research Report 1695). Alexandria, VA. U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A313 293)

Elliott, G. S., Sterling, B. S., & Lickteig, C. W. (1998). System evaluation report for task force tactical operations center (TOC) reengineering. U.S. Army Operational Test and Evaluations Command Test and Evaluation Coordination (TECO) Office, Fort Knox, Kentucky, 40121-5000

Graves, C. R., Campbell, C. H., Deter, D. E., & Quinkert, K. A. (1997). Combined arms operations at brigade level, realistically achieved through simulation I (COBRAS I): Report on development and lessons learned (Research Report 1719). Alexandria VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Klein, G., & Crandall, B. (1996). Recognition-primed decision strategies (Research Note 96-36). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Leibrecht, B. C., Meade, G. A., Schmidt, J. H., Doherty, W. J., & Lickteig, C. W. (1994). Evaluation of the combat vehicle command and control system: Operational effectiveness of an armor battalion (Technical Report 998). Alexandria VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Lickteig, C. W. (1996). Research methods for advanced warfighting experiments (ARI Technical Report 1047). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A292 718)

Lickteig, C. W. & Throne, M. H. (in preparation). Applying digital technologies to training: A focus on pictorial communication (ARI Technical Report). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

U.S. Army Armor Center (December 1997). User's manual for the battalion TOC CEP. Available: Commander, U.S. Army Armor Center, ATTN: ATZK-MWT, Fort Knox, KY 40121-5000.

U.S. Army Armor Center (April 1998). Battle lab experiment final report (BLEFR) for battle command reengineering I concept experimentation program (CEP). Available: Commander, U.S. Army Armor Center, ATTN: ATZK-MWT, Fort Knox, KY 40121-5000.

Appendix A

Information Requirements Questionnaire

Insert your call sign in this space: _____ PT#60-03A

Information Requirements

Purpose: A key issue with respect to future information systems is how well they meet the information requirements of the commander and his unit. The purpose of this questionnaire is to help address that issue with respect to **your duty position** during this CEP.

Instructions: Consider the information required for your assigned duty position during the course of a mission. We would like you to assess how well the information systems provided at your duty station during this CEP met the information requirements of your duty position.

To do that, we ask you to do three things:

1. Identify the types of information required in your CEP duty position.
2. Assess how well each identified requirement was met by your information systems.
3. Recommend how your information requirements might be better met.

A sample item is provided below to illustrate how we would like you to do those three things.

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Warning Order	☐	☑	☐	☑	☐

Recommend: _____

1. First, consider the type of information listed in an item, such as Warning Order in the above sample. If that information is not a requirement for your duty position, check Not Required and **skip** to the next item. If it is required, check Required, as in the above sample.

2. If you check Required, then assess how well that requirement (Reqmt) was met. To do so, check either Reqmt Not Met, Reqmt Met (as in the sample), or Reqmt Exceeded.

3. If you have any recommendations on how this information requirement might be better met, please provide them on the Recommend line. If you have no recommendations, skip to the next item.

This questionnaire identifies **some** types of information, such as Warning Order.
What **other** information requirements need to be met for your duty position?
How well were they met?

The lower portion of each page will ask you to identify any other information requirements, as in the sample item below.

Type of Information Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
_____	☐	☐	☐

Recommend: _____

For the sample item above, first identify in writing that information on the line under Type of Information Required. Then, as for the Warning Order sample item above, assess how well that requirement was meet. Finally, provide any recommendations to better meet that requirement on the Recommend line.

This questionnaire is organized by Mission, Enemy, Terrain, Troops and Time (METT-T). Each METT-T factor is addressed in order and on a separate page. The next page, for example, is titled Mission Related Information Requirements.

Thank you.

Mission Related Information Requirements

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Warning Order	☐	☐	☐	☐	☐

Recommend: ______________________________

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Operations Order	☐	☐	☐	☐	☐

Recommend: ______________________________

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Operations Overlay	☐	☐	☐	☐	☐

Recommend: ______________________________

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Commander's Intent	☐	☐	☐	☐	☐

Recommend: ______________________________

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Course of Action	☐	☐	☐	☐	☐

Recommend: ______________________________

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Fragmentary Order	☐	☐	☐	☐	☐

Recommend: ______________________________

Are there any other types of **Mission** related information required by your duty position? If so, please identify the type of information required below and then assess how well that information requirement was met. In the Recommend section, provide your recommendations on how that information requirement might be better met.

Type of Information Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
______________________	☐	☐	☐

Recommend: ______________________________

Type of Information Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
______________________	☐	☐	☐

Recommend: ______________________________

Type of Information Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
______________________	☐	☐	☐

Recommend: ______________________________

Type of Information Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
______________________	☐	☐	☐

Recommend: ______________________________

Enemy Related Information Requirements

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Enemy's Location	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Enemy's Composition	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Enemy's Disposition	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Enemy's Ability to See	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Enemy's Ability to Move	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Enemy's Ability to Shoot	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Enemy's Ability to Communicate	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Enemy's Ability to Sustain	☐	☐	☐	☐	☐

Recommend: _____

Are there any other types of **Enemy** related information required by your duty position? If so, please identify the type of information required below and then assess how well that information requirement was met. In the Recommend section, provide your recommendations on how that information requirement might be better met.

Type of Information Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
_____	☐	☐	☐

Recommend: _____

Type of Information Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
_____	☐	☐	☐

Recommend: _____

Terrain Related Information Requirements

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Observation	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Cover	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Concealment	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Obstacles	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Key Terrain	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Approach Avenues	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Weather	☐	☐	☐	☐	☐

Recommend: _____

Are there any other types of **Terrain** related information required by your duty position? If so, please identify the type of information required below and then assess how well that information requirement was met. In the Recommend section, provide your recommendations on how that information requirement might be better met.

Type of Information Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
_____	☐	☐	☐

Recommend: _____

Type of Information Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
_____	☐	☐	☐

Recommend: _____

Type of Information Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
_____	☐	☐	☐

Recommend: _____

Troop Related Information Requirements

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Friendly's Location	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Friendly's Organization	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Friendly's Ability to See	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Friendly's Ability to Move	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Friendly's Ability to Shoot	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Friendly's Ability to Communicate	☐	☐	☐	☐	☐

Recommend: _____

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Friendly's Ability to Sustain	☐	☐	☐	☐	☐

Recommend: _____

Are there any other types of **Troop** related information required by your duty position? If so, please identify the type of information required below and then assess how well that information requirement was met. In the Recommend section, provide your recommendations on how that information requirement might be better met.

Type of Information Required _____	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
	☐	☐	☐

Recommend: _____

Type of Information Required _____	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
	☐	☐	☐

Recommend: _____

Type of Information Required _____	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
	☐	☐	☐

Recommend: _____

Time Related Information Requirements

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Time to Plan	☐	☐	☐	☐	☐

Recommend: ____________________

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Time to Wargame	☐	☐	☐	☐	☐

Recommend: ____________________

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Time to Prepare	☐	☐	☐	☐	☐

Recommend: ____________________

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Time to Rehearse	☐	☐	☐	☐	☐

Recommend: ____________________

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Time to Execute	☐	☐	☐	☐	☐

Recommend: ____________________

	Not Required	Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
Time to Sync Execute	☐	☐	☐	☐	☐

Recommend: ____________________

Are there any other types of **Time** related information required by your duty position? If so, please identify the type of information required below and then assess how well that information requirement was met. In the Recommend section, provide your recommendations on how that information requirement might be better met.

Type of Information Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
____________________	☐	☐	☐

Recommend: ____________________

Type of Information Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
____________________	☐	☐	☐

Recommend: ____________________

Type of Information Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
____________________	☐	☐	☐

Recommend: ____________________

Type of Information Required	Reqmt Not Met	Reqmt Met	Reqmt Exceeded
____________________	☐	☐	☐

Recommend: ____________________

Appendix B

Military Decision Making Process (MDMP) Questionnaire

CALL SIGN

MILITARY DECISION MAKING PROCESS

Mission *(circle one)*	**Command Post or node** *(circle one)*	**Position** *(circle one)*	
MTC	Command Group	Bn Cdr	Enemy Ops Off
Defend	Current Ops	XO	Ops SGT
ATK	Plans	Battle Captain	Plans SGT
Exit Questionnaire	Floor BCV	Ops Off	Sensor NCO
		Friendly Ops Off	OC

Listed below are the seven (7) major steps of the Military Decision Making Process (MDMP), for instance used in tactical decision making. Under the steps the sub-steps involved in each step are also listed. Please indicate, by checking the appropriate blocks whether that step or sub-step, in the restructured Tactical Operations Center (TOC), was:

UNCHANGED – The entire step was performed the same way in the restructured TOC as in a conventional TOC. If you check "unchanged" for the step, do not check any blocks for the sub-step under that step. That is, if the entire step is unchanged, all sub-steps must also be unchanged.

CHANGED – The step or sub-step was still performed, but in a different way in the restructured TOC than in a conventional TOC. Under the comments section, please describe how the step or sub-step was performed differently. Individual sub-steps under the step may be unchanged, changed, combined or eliminated.

COMBINED – The step or sub-step was performed as a part of another step or sub-step in the MDMP in the restructured TOC. Under the comments section, indicate which other step or sub-step was combined with it. Again, sub-steps under the step may be unchanged, changed, combined or eliminated.

ELIMINATED – The entire step no longer needs to be performed at all in the restructured TOC. If you check "eliminated" for the step, do not check any blocks for the sub-step under that step. That is, if the entire step is eliminated, all sub-steps must also be eliminated.

	UNCHANGED	CHANGED	COMBINED	ELIMINATED
MISSION ANALYSIS				
- Prepare initial Intelligence Preparation of the Battlefield				
- Analyze higher mission				
- Analyze Bde order				
- Assess risk				
- Briefing and approval				

Comments: (required if changed or combined are checked) Also, please include the addition of any related new steps or sub-steps.

	UNCHANGED	CHANGED	COMBINED	ELIMINATED
COURSE OF ACTION (COA) DEVELOPMENT				
- Analyze Cdr's guidance				
- Analyze relative combat power				
- Generate conceptual possibilities				
- Develop scheme of maneuver				
- Incorporate all battlefield operating systems				

Comments: (required if changed or combined are checked) Also, please include the addition of any related new steps or sub-steps.

	UNCHANGED	CHANGED	COMBINED	ELIMINATED
WARGAMING				
- Follow wargaming method				
- Employ all friendly and enemy forces/resources				
- Identify critical events and decision points				
- Record results				
- Apply action/reaction/counteraction				
- Assess results				

Comments: (required if changed or combined are checked) Also, please include the addition of any related new steps or sub-steps.

	UNCHANGED	CHANGED	COMBINED	ELIMINATED
COURSE OF ACTION COMPARISON				
- Select comparison method				
- Determine decision criteria and assign weighting values to criteria				
- Record results (COA decision matrix)				

Comments: (required if changed or combined are checked) Also, please include the addition of any related new steps or sub-steps.

	UNCHANGED	CHANGED	COMBINED	ELIMINATED
ORDERS PREPARATION				
- Incorporate CDR's guidance				
- Identify who, what, where, when & why				
- Incorporate Battlefield Operating Systems plans				
- Review & approve				

Comments: (required if changed or combined are checked) Also, please include the addition of any related new steps or sub-steps.

	UNCHANGED	CHANGED	COMBINED	ELIMINATED
REHEARSAL				
- Define the standard				
- Orient participants to terrain				
- Verbalize concept of the operation				
- Select key events to rehearse				
- Describe enemy COAs				
- Focus on purpose of rehearsal (Decision Support Template, branches & Sequels, synchronization)				

Comments: (required if changed or combined are circled) Also, please include the addition of any related new steps or sub-steps.

	UNCHANGED	CHANGED	COMBINED	ELIMINATED
MISSION EXECUTION & TRANSITION				

Comments: (required if changed or combined are circled) Also, please include the addition of any related new steps or sub-steps.

Rate the efficiency and effectiveness with which each of the seven (7) major steps of the MDMP were performed in its restructured TOC by circling the appropriate number. If a step was not performed (i.e. eliminated) leave blank.

MISSION ANALYSIS		
Inefficient	Moderately Efficient	Very Efficient
0	1	2
Ineffective	Moderately Effective	Very Effective
0	1	2

COURSE OF ACTION DEVELOPMENT		
Inefficient	Moderately Efficient	Very Efficient
0	1	2
Ineffective	Moderately Effective	Very Effective
0	1	2

WARGAMING		
Inefficient	Moderately Efficient	Very Efficient
0	1	2
Ineffective	Moderately Effective	Very Effective
0	1	2

COURSE OF ACTION COMPARISON		
Inefficient	Moderately Efficient	Very Efficient
0	1	2
Ineffective	Moderately Effective	Very Effective
0	1	2

ORDERS PREPARATION		
Inefficient	Moderately Efficient	Very Efficient
0	1	2
Ineffective	Moderately Effective	Very Effective
0	1	2

REHEARSAL		
Inefficient	Moderately Efficient	Very Efficient
0	1	2
Ineffective	Moderately Effective	Very Effective
0	1	2

MISSION EXECUTION & TRANSITION		
Inefficient	Moderately Efficient	Very Efficient
0	1	2
Ineffective	Moderately Effective	Very Effective
0	1	2

Appendix C

Comments on Military Decision Making Process (MDMP)

Mission Analysis
(n = 45)

Comment	Number
More streamlined – faster	10
Significantly changed due to technology	10
IPB done differently because of tools	6
No formal briefing	5
Done in plans vehicle	3
Performed in current Ops	3
Must consider ADA risk for UAV	2
XO C2V not involved	2
More terrain analysis than last mission	1
Analysis individualized due to technology	1
Current Ops executed the R & S plan	1
Brigade SITEMP useless	1
Participated via voice with other Operations officers	1

Course of Action Development
(n = 32)

Comment	Number
Tools provide positive capability (including updating situation)	7
Must have maneuver-fire support-intelligence fusion (i.e.; too few BOS included)	6
S3 develops COAs	3
Struggled to develop two COAs	2
Relative combat power to force on force ratios not performed	2
S2 develops COAs	2
Should be quicker	1
Location and time somewhat changed	1
Rely mostly on indirect fire	1
COA development individualized	1
Did not have capacity to do it right this time	1
COA development and wargaming combined	1
Add BOS at rehearsal/wargaming	1
Commander's guidance is now transparent	1
Is much quicker	1
Less is better at battalion – use company commanders to develop COAs	1

Wargaming
(n = 41)

Comment	Number
Done with white board and company commanders	7
More abridged	6
Results recorded in white board	3
S3 wargamed	2
No recording or assessing of results	2
No specific method used	2
No synchronization matrix	2
Plans C2V issued the product	2
Combined with rehearsal	2
No staff huddle with synch matrix	1
Need assimilation capability that allows you to fight the plan	1
Only key events wargamed	1
Done by teleconference versus terrain model	1
Driven by commander	1
Plans officers all drew graphics for commander's COAs	1
Steps combined with COA development	1
Fewer people involved	1
Excellent – solution transparent	1
No DST consummated	1
Less is better at battalion level	1
Flexible schemes can replace execution of a plan	1
Other BOS not incorporated	1

Course of Action Comparison
(n = 35)

Comment	Number
No decision matrix used	6
Conducted by battalion commander	5
Less necessary – solution transparent	4
Conducted by S3	3
No formal criteria used	3
Results not recorded	2
Did not weigh criteria	1
Done with white board	1
Decision brief eliminated	1
Demonstrates the value of COA development	1
Get verbal feedback on COA	1
Must still stress what is important to the commander	1
Allows Company commanders to start working detailed analysis of their requirements	1
Combined with wargaming	1
Eliminated	1
Use of plan view display allowed best enemy route to be observed	1
Very rudimentary but effective	1
Less is better – COA can change	1

Orders Preparation
(n = 19)

Comment	Number
FRAGO and graphics on white board with some verbiage	5
Done more quickly	3
Largely unchanged	2
Need to incorporate all BOS	2
Less formal – event driven	2
Done by S3	1
Does not need detail, just key BOS required	1
OPORD format revised due to fluid exchange of information and increased situational awareness	1
BOS integrated fully at rehearsal	1
Programmed OPORD format would speed things up	1

Rehearsal
(n = 41)

Comments	Number
Conducted with company commanders via white board	8
No formal DST	4
Revised plan based on rehearsal (Current Ops)	4
Performed via FM – synchronization drill, not sand table	2
Not focused on key events	2
Better rehearsal this time	2
Battle Captain acted as recorder	1
No notional staff – a big leap	1
Can talk to DST and branches if needed versus ROC drill	1
No company commander's brief back	1
Direct fire distribution not rehearsed	1
Changed only in aspect of medium (teleconference)	1
May be performed over email	1
May be unnecessary	1
Looked more like a brief by battalion commander	1
Combined with COA	1
All pieces required were present	1
The commander had a better plan	1
Some fire support questions unanswered	1
Still important	1
Players can make this more effective	1
Still meets goals	1
XO not involved	1
Methods and tools have changed	1
Commander is key person	1

Mission Execution
(n = 39)

Comments	Number
Current Ops executed the R&S plan	6
Greater visualization for the commander	5
Reaction time to events quicker	3
Less spot reports	2
Less planning up front	2
Must use this technology, think "out of the box"	2
Artillery fired from C2Vs	2
More efficient & effective	2
Fires controlled by current operations	2
No calling for front line trace	1
Calls for fire do not clog radio	1
Fires need to be managed by commander's track	1
No CSS played	1
Continue to languish with doctrine of wait until conditions are perfect to LD	1
Must deconflict fires and close air support	1
Fires and routes plan synchronized via PVD	1
S3 moved to plans track	1
Duties of plans C2V unclear in execution	1
Command group friendly Ops involved in CSS, terrain analysis	1
The XO monitored current Ops and synchronized assets	1
Tools used by commander to do some terrain analysis	1
XO synchronized fires	1

Appendix D

List of Acronyms

ABCS	Army Battle Command System
ACR	Armored Cavalry Regiment
ADA	Air Defense Artillery
AFRU	Armored Forces Research Unit
AOAC	Armor Officer Advanced Course
AR	assess results
ARI	U.S. Army Research Institute
ASAS	All Source Analysis System
ATCCS	Army Tactical Command and Control System
AWE	Army Warfighting Experiment
BCV	battle command vehicle
Bde	brigade
BOS	battlefield operating system
C^2V	command & control vehicle
C^4I	command, control, communication, computer, and intelligence
CCIR	commander's critical information requirements
Cdr	commander
CEP	concept experimentation program
CGSC	Command and General Staff College
COA	course of action
CP	command post
CPT	Captain
CSS	combat service support
CTCP	combat trains command post
D	dimensional
DARPA	Defense Advanced Research Products Agency
DIS	distributed interactive simulation
DST	decision support template
E-MAIL	electronic mail
FASTTRAIN	Force XXI Training Methods and Strategies
FBC	Future Battlefield Conditions
FM	field manual
FRAGO	fragmentary order
IPB	intelligence preparation of the battlefield
IR	information requirement
JSTARS	Joint Surveillance Target Attack Radar System
MAJ	Major
MBBL	Mounted Battlespace Battle Lab
MDMP	military decision making process
ME&T	mission execution and transition
METT-T	mission, enemy, terrain, troops, and time
METT-TC	mission, enemy, terrain, troops, time, and civilians
ModSAF	modular semi-automated forces
MOA	memorandum of agreement
MOS	military occupational specialty
MWTB	Mounted Warfare Test Bed

NCO	noncommissioned officer
NTC	National Training Center
O/C	observer/controller
OIC	officer in charge
OPFOR	opposing force
OPORD	operations order
Ops	operations
PVD	plan view display
RPD	recognition primed decision
RR	record results
R&S	reconnaissance and surveillance
S2	intelligence officer
S3	operations officer
SFC	Sergeant First Class
SGT	Sergeant
SITEMP	situation template
SITMAP	situation map
SOP	standing operating procedure
SSG	staff sergeant
TECO	Test and Evaluation Coordination Office
TOC	tactical operations center
TTP	tactics, techniques, and procedures
UAV	unmanned aerial vehicle
USAARMC	United States Army Armor Center
VTC	video teleconference
XO	executive officer